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With Ten Plates.

Edited by JAMES W. DAVIS, F.S.A., F.L.S.

1883.

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THE PHOTOGRAPH

Issued with this part of the Proceedings exhibits a section in the cliff, a short distance beyond the archway on the north side of the Castle Hill, at Scarborough. The Dogger Beds are exposed at the base of the Upper Calcareous Grit. The peculiar nodular masses called "Doggers" project prominently from the surrounding surface.

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PROCEEDINGS

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1883.

ADDRESS ON THE CONNECTION BETWEEN GEOLOGY AND ARCHÆOLOGY.

BY THE REV. W. C. LUKIS, M.A., F.S.A.

WE are met together to welcome a society whose noble President is in a far distant land, occupying the highest post of distinction and trust that can be conferred by Her Majesty upon one of her subjects. The citizens of Ripon, and residents in the neighbourhood, rejoice to see him discharging the responsible duties of his high Vice-regal office with that energy and unremitting attention to public business, which are a strongly marked feature in his character; but if any one has reason to regret that his Lordship is in India, and not in this room to-day, it is myself.

Between forty and fifty years ago I spent a most enjoyable day in an aquatic excursion from Cambridge down the sedgy river Cam as far as Ely, in company with four gentlemen, whose names probably not one person in this room is ignorant of, and with one or more of whom some here present have had intimate personal acquaintance. With that too-short day my geological study, practically applied, may be said to have begun and ended. These four gentlemen were Professors Sedgwick, Phillips, Henslow, and Ansted. It was a day of my Cambridge life which I have always cherished in memory.

Your accomplis[illegible]retary, Mr. James W. Davis, has written an exceedingly intere[illegible]graphical notice of Professor Phillips, who, for the long perio[illegible]ty years was so actively engaged in investigating Yorkshire [illegible]d in giving lectures in the county, that he might almost be cl[illegible] a fellow-countryman of yours; which notice has been printe[illegible] VIII., of the Society's *Proceedings*. In it he remarks:—"M[illegible]ction is very fresh of his kind "and genial face, his winning an[illegible]aging smile, the ever-ready "and wise words with which he b[illegible] and enlivened the most "perplexing question, and the deep i[illegible]e and great experience "which lay below and prompted al[illegible]bservations." These remarks are especially applicable to Pro[illegible]dgwick, who, being a Yorkshireman by birth, possessed in [illegible]rkable degree the faculty of attracting the admiration, and [illegible] the affectionate respect of all the members of the Universit[illegible]d young. If his features were somewhat rugged, his eloqu[illegible] animation in public lecturing, and in social converse, were [illegible]easing, and his soul overflowed with so much wit and humour [illegible]t he was a most agreeable and fascinating companion. But over and above these attractive qualities, he was an earnest and sincere believer in the Great and Almighty Architect of the Universe, and, when lecturing, was always careful to impress upon the minds of the young students of science that no geological discoveries would ever be found to conflict with the truth of the Sacred History.

The title of the Institution, which we have the honour to welcome to this city, would seem to imply, upon the face of it, that its sphere of inquiry is limited to the geology of Yorkshire, and to those natural formations which, by the application of machinery and other appliances are rendered beneficial to mankind.

I propose to point out in very few words in my brief address, that this would be a too-narrow view, and in what manner archæology is connected with it. If the researches of the society's members were confined to the field of geology and mechanical science alone, however important to the community at large, and interesting to many, they might prove, they would not satisfy and interest everybody. All of us are not geologists, nor are we all

absorbed in matters relating to practical engineering; and those among us who reside on the extreme eastern verge of the Riding, far removed from the great centres of mineral wealth and industrial activity, cannot be expected to take the most lively pleasure in viewing and considering the consecutive order, the dip, the contortions and the faults of strata; in discoveries of new coal and ironstone beds, and lead veins; or in new and ingenious mechanical contrivances for extracting minerals from the earth, and making them fit for man's use.

But under the further title of Polytechnic, much is included that might be thought, and perhaps has been thought, outside the society's field of operations, and awakens the interest of non-geologists. Archæology, *e.g.* in many of its bearings is so interwoven with, or rather dovetailed into geology, mineralogy, and the arts and sciences, that it cannot be entirely excluded, and the society has wisely opened its portals to it. It is true that in its origin the Institution was founded for the purpose of directing the studies of its members to those subjects which have special reference to the geology and industries of the West-Riding of Yorkshire, and for many years this object was kept steadily in view, but after a while one member, and then another, without protest from the governing body, gave papers on British, Roman, and other remains, not found in the county, some of which papers bore in no sense upon the geology and industries of the Riding. I confess I was one of the culprits in 1869, at which period an unusual number of alien subjects were introduced, and no doubt I was one of the main causes of a desire on the part of the Council, in 1872, to restore the society to what was conceived to be its original legitimate work.

I have said above that there are questions relating to manufacturers and industry generally, which, being archæological, are not unworthy of the society's recognition or inconsistent with its aim. The tools and weapons of the primitive inhabitants of Yorkshire, and the materials with which they have been formed; the clothing which covered the people, whether manufactured out of woollen stuff or leather; the art of the primeval potter; the implements employed in agricultural and mining purposes; what

grain and fruits of the earth were cultivated; what animals were bred; what were the horse trappings and chariots; what the design, materials, and fabrication of personal ornaments; of what kind were their dwelling-houses and fortresses; and even the materials and construction of their coffins—all these matters, which belong to the domain of archæology, are yet legitimate branches of scientific study which no Polytechnic Society can fairly exclude, for in tracing out the development of industry no hard and fast line could be drawn beyond which research would be unnecessary and uninstructive, not to say unattractive to some among us.

These remarks will also apply to the Roman, Saxon, Danish, and Norman occupation of Yorkshire, and to the influences which the productions of these invading races have exercised upon the modern industries of the county, and of the country generally. There is no doubt that each of these peoples have left some traces of their skill and ingenuity in manufacture among the subjugated and oft-times cruelly oppressed inhabitants, of which we are reaping the benefit now; and if it had not been for archæological researches, and the publication of those researches, many amongst us would never have known to what extent we are indebted to them for much that we may have vauntingly and in our ignorance taken credit to ourselves for having originated. The explorations of antiquarians have been instrumental, not only in bringing to light numerous articles of various kinds which for honest purity of materials, elegance of form and design, and excellence of workmanship cannot be excelled in the present day, but which on being reproduced by our manufacturers have found a ready sale, because the public eye has been captivated, and public taste educated. Thus, moderns have imitated the works of the ancients, by doing which, they have to some extent confessed their own inferiority; and this has been the humbling but beneficial result of archæological investigation.

NOTES ON THE CARBONIFEROUS POLYZOA OF WEST YORKSHIRE AND DERBYSHIRE—*(AN ATTEMPT TO IDENTIFY PHILLIPS' SPECIES).*

BY GEORGE ROBERT VINE.

FOR many years past I have made several unavailing attempts to identify, and re-describe, the Carboniferous Polyzoa of our older Palæontologists. I ascribe my failure rather to the scarcity of material than to any want of distinctness on the part of the original describers. There is, as a matter of course, the original specimens—especially of Phillips and McCoy—but these were not available for my work, and I prefered to depend upon later findings, comparing the new with the written details of authors. It is pretty well known, that after the publication of Goldfuss' Petrifacta Germaniæ, that this work was the source of much of our information respecting Fossil Zoophyta; and accordingly many of our British examples were furnished with the generic, if not the specific names of Goldfuss. In the Petrifacta there are but few species figured or described from Carboniferous rocks. To this cause we owe the original descriptions of Phillips, who, writing only a year or so after the issue of the German work, was able to furnish a rather goodly list of Carboniferous species. In his edition of the Geology of Yorkshire, p. 195 (1829 Ed.) Phillips says "Few of the Mountain Limestone districts of England are deficient in remains of Corals, Crinoidea, &c., whether as in Derbyshire and Mendip we contemplate the lower thick mass of Calcareous rock, or as in the North-West of Yorkshire, and in Northumberland examine the thinner portion which alternate with shales, gritstones, &c. Several of the same species are common in the whole range of the formation, and perhaps, if the local catalogues were more complete and more correct, it is probable that a very general conformity would be found to prevail in this respect."

Since the issue of the Geology of Yorkshire, a very steady progress has been made in either the discovery of new Carboniferous species of Polyzoa in Great Britain, or in showing the wider range of species identical with those described by Phillips. McCoy in his various works added much to our knowledge of Carboniferous Polyzoa,—and later still Prof. Young, and Mr. John Young, of

Glasgow have added to the number of species previously described, and have furnished many interesting details of heretofore unknown characters in some of the species described by Phillips in his "Palæozoic Fossils." Mr. Robert Etheridge, jun., has likewise done good work in his professional capacity on the Scotch Geological survey.

The present paper is the result of a careful study, for the purpose of identification, of the types of John Phillips, as described and figured in the Geology of Yorkshire, or referred to in the Palæozoic Fossils. I have previously examined some of the North Yorkshire Polyzoa,* and I have shown that many of these have a closer relationship with Scotch, than with Yorkshire types. The remarks which will follow are founded upon a very fine series of Carboniferous Polyzoa from Derbyshire and Yorkshire, collected by Mr. John Aitken, F.G.S., of Manchester. The Derbyshire species have a closer relationship with the Yorkshire, or Phillips' types, but hardly any with the Irish or Scotch examples bearing the same names.

Mr. Phillips in the work already cited *(Geol. of Yorks.)*, and later still in the Palæozoic Foss. of Devon, &c., described and figured as Zoophyta, a goodly number of Polyzoa. Some of the species in the latter work are identical with those found in the Carboniferous rocks of Derbyshire, Yorkshire, Wales, and Scotland, in fact, many of the species are widely distributed in the Limestones and Shales generally. At the time when Phillips wrote, very little attention was given to either classification or growth, hence the multiplicity of species if the fragments found differed in the least particular from others that had been previously noted. There was no fixed rule given for the purpose of comparison, sometimes a cast, or the reverse would be described as a new species, and in all probability the obverse of one or other of those would be again given as likewise new. Several of the species figured in the Geology of Yorkshire are in this chaotic condition, and there is a great difficulty in the proper identification of species whenever or wherever new ground is broken. Because of this very plausible demurrer others have added to the confusion, and the fresh findings have been again

* Transactions of the Yorks. Geol. and Polytech. Soc., 1881.

christened, perplexing alike the Palæontologist as well as the ordinary Geological student. Phillips has described nine species of Retepora (Fenestella), only three of which can be retained as tpyical, *R. membranacea*, *nodulosa*, *and polyporata*; *R. laxa* must be referred to a different genus. As *Millepora*, Phillips described two species of *Ceriopora* in the Geology of Yorkshire, *Millepora rhombifera* and *interporosa*, and in the Palæozoic Fossils two others, *M. gracilis* and *similis*, which are more or less abundant in the Carboniferous formation. Two other species, *M. spicularis* and *M. oculata*, have been referred by Morris (Cat. of Brit. Foss.), to the genus *Pustulopera* Blainville. The *Retepora pluma* of Phillips belongs to at least two types of Polyzoa.

As the whole of the Palæozoic Fenestellidæ * have received from Mr. G. W. Shrubsole very marked attention, I am saved the necessity of furnishing any elaborate details, especially in respect to the Carboniferous species. Previous to the labours of Mr. Shrubsole there were about twenty-six described *Fenestella*,—these have been reduced to about five typical forms, and the elaborate details given by the author in his two papers, cause my labours on this group to be a comparatively easy one. I shall, therefore, accept without unnecessary discussion, Mr. Shrubsole's work, adopt the specific characters he has given, and also the types restricted or received by him. I do not accept the whole of the synonyms, for the simple reason that I desire to keep before me the labours of Phillips. I do not doubt the accuracy of the synonyms, because I believe, generally speaking, that Mr. Shrubsole is right. There is one advantage to be derived from purely local work over that of the more general labours in the study of our British Palæozoic Polyzoa. In the local work we are compelled to direct particular attention to the types before us, because we find that whenever we recede from any life region there are divergencies, if not in the cell characters, at least in the habits of species which are worthy of much closer study than has yet been given to the subject. In the following pages I have described the specimens before me, and because of this I have not

* A Review of Brit. Carb. *Fenestellidæ*, Quart. Journ. Geol. Soc., May, 1879, further Notes *ibid* May, 1881.

given the larger, and more general descriptions of Mr. Shrubsole which are founded upon a large suit of Carboniferous *Fenestella*, and from very wide localities.

Genus FENESTELLA, Lonsdale.

"*Zoarium*, a calcareous reticulate expansion, either flat, conical, or cup-shaped, formed of slender bifurcating branches (interstices), poriferous on one face, connected by non-poriferous bars (dissepiments), forming an open network. *Zoœcia* immersed in the branches and arranged in two longitudinal rows divided by a central 'superficial' keel, on which are often prominences. Orifice of Zoœcia small, circular, and prominent when preserved." (Carb. Fenestellidæ, G. W. S., p. 179 *Quart. Jour. Geol. Soc.*, May, 1881.

1. FENESTELLA PLEBIA. McCoy, Syn. *Carb. Fos., Ireland*, p. 29, Fig. 3.
= *R. flustriformis*, Phillips, *Geol. Yorkshire*, pl. I., Figs. 11-12.
= *R. irregularis*, ,, ,, ,, ,, 21-22.
= *R. undulata*, ,, ,, ,, ,, 16-18.

Phillips' descriptions of these species are brief and unsatisfactory. Of the first, very few particulars are given: *R. irreuglaris* and *R. undulata* are different portions of the same species, and Mr. Shrubsole has done well in selecting the well-described *F. plebia*, McCoy, as the type of this group. In the Derbyshire specimen the Zoarium is a flat expansion, the dissepiments are thin, and the fenestrules are oval, with four or five zoœcia on each side, and only five fenestrules occupy the space of two lines measured transversely, four in the same space in a longitudinal direction. There is nothing in this that would interfere with typical *F. plebia*, other parts of the Zoarium would give different results. I have not the least doubt but that this is the typical *Retepora* and Millepora *flustriformis* of Phillips and Martin. Phillips' figure is that of a cast, and the same specimens show that the mere casts of the fenestrules would give in a drawing, precisely the same result as in Figs. 11 and 12. On another part of the Zoarium there is a thin crust of *Hemitrypa*, similar to that referred to in my previous paper (*Hurst and Richmond Polyzoa*, p. 335, 1881). The specimens of *F. plebia* from Settle are more in accord with the Welsh and Scotch examples of the type: the "fenestrules are equal, rectangular, from two to three times as long as wide."

Localities: Derbyshire, Castleton; Yorkshire, Settle. Widely distributed, and ranging from Lower Carboniferous to Permian.

2. Fenestella membranacea, Phillips' *Geol. Yorks.*, Pl. I., Figs. 1 to 6.
= *R. flabellata*, Phillips' *Geol. Yorks.*, Pl. I., Fig. 7-10.
= *R. tenuifila* ,, ,, ,, ,, 23-24-25.

I have only poor specimens of the type *R. flabellata*, Phillips; it is a portion of the flat expansion of the upper portion of the Zoarium. The branches are rounded straight and in parallel lines; the dissepiments are fine, fenestrules oblong, slightly wider than the branches, and the average number to two lines, are about eight transversely, and five longitudinally. The Zoœcia are small and the orifice circular, from three to four occupy the length of the fenestrule.

Some very interesting particulars are given by Mr. Shrubsole respecting the development of this species, and in all probability the whole of his synonyms are correct, but I am not able, for want of material, to endorse the whole.

Localities: Derbyshire, Castleton; (Phillips: Bolland, Harrogate, Richmond, Hawes, Whitewell, Middleham).

3. Fenestella nodulosa (?) Phillips. *Geol. Yorks.* pl. I., Figs. 31, 32, 33
= *F. Frutex (?)* McCoy (*Syn. Carb. Foss. Ireland*, pl. XVIII., Fig. 10).

I have a fine specimen of *Fenestella* and it appears to me to be referable to *F. nodulosa;* and yet it might have very well served as the type of *F. hemispherica* McCoy. It is hemispherical and cup shaped, otherwise it is characteristically *F. nodulosa.* The Zoarium begins as a small base, enlarging and expanding by growth till at the distal part it is nearly two inches in breadth. The zoœcia open in the inside of the cup. In this respect it closely resembles the flabelliform growth of *F. frutex* McCoy, a name which Mr. Shrubsole gives as a Syn. of *F. nodulosa.* Although I have marked the species with a note of interrogation I have but little hesitency in accepting the character as given in the paper on Carboniferous Fenestellida, p. 183. In comparing, however, this with a Scotch specimen of *F. nodulosa* I cannot help remarking on the difference in the habit of the two types. The Derbyshire specimen is a deep water, and the Scotch a comparatively shallow water form, and in the first, the root, branches, and cells are strong and robust, whereof

in the latter the whole framework is delicate or slender. Phillips' description appears to have been given from a flattened specimen. *Zoarium*, "Radiating dissepiments thin, fenestrules arcuato quadrate, pores usually one at the middle undulating the margin, and one at each dissepiment," the following refers to the remains of the spiny processes along the keel, "Smaller pores in the interstices."

Since this was written I have received from Mr. Aitken another fragment of *F. nodulosa* that might have served as the type of Fig. 31, pl. I., *(Geol. of Yorks.)* It is far more delicate and characteristic of the species than the above. With this specimen before me I am obliged to say that very few descriptions could be clearer than that given by Phillips, as already quoted, but I have no desire to remove the (?) from the above description.

Localities: (Phillips: Whitewell, Greenhow Hill, Harrogate). Castleton, Derbyshire; Settle, Yorkshire.

4. Fenestella polyporata Phillips, *Geol. Yorks.* pl. I., Fig. 19, 20. *F. multiporata*, McCoy, *Syn. Carb. Foss. Ireland*, pl. XXVIII, Flg. 9.

I have before me several specimens of this species, the largest of the British Fenestellidæ as regards the size of the fenestrules. Mr. Shrubsole who has had the advantage of comparing the type specimens of McCoy, or at least specimens from the same locality says—"It is subject to considerable variation." Prof. McCoy in his arrangement of the *Fenestella* assigned the smaller type to Phillips' *F. polyporata*, and the type with the larger development and greater number of pores he described as *F. multiporata*, but as both conform so well to the type in other respects, there is no reason for the division (Op. cit. p. 186.)

Zoarium foliaceous branches large and rounded, fenestrules large and elongated, four in the space of a line measured transversely, and two in the same space if measured longitudinally, keel rounded and well developed. *Zoœcia* from five to nine in the length of the fenestrule, openings small, occasionally prominent. Dissepiments, thin and placed at irregular distances.

Localities: The only locality given by Phillips is Florence Court. Castleton, Derbyshire; Poolvash, Isle of Man; (Small fragments) Settle, Yorkshire. These are the only species of *Fenestella*

that I have any record of in West Yorkshire or Derbyshire.

With regard to *Fenestella flustriformis* as described by Martin, I have thought that the following quotation from the *Petrefacta Derbiensca*, Vol. I., Pl. 43–45, Figs. 1 and 2, and Fig. 3, may be valuable. It is the only Polyzoa figured or described in the work.

"Erismatholithus milleporites? *(flustriformis).*

Plano-foliaceous, reticulatis, poris minutis, sub-obsolelis sparsis.

Fossil coral, originally a Millepora? Plano-foliaceous or flat, and thinly expanded like a leaf; its form or outline is uncertain. (Note.—All the specimens I have yet collected appear to be only fragments or portions of the original). Its fabric open and reticulated, somewhat resembling the coralline distinguished by the title of *flustræ*. The surface of the fibres forming the reticulation, roughened with minute, indistinct scattered pores; not, however, visible without the assistance of a magnifier. Common in Limestone, Middleton."

I am unable to identify Martin's species in the Limestone of Middleton from either the description or figures. Fragments of *F. plebia.* and *F. nodulosa* are common, and I see no reason to prevent me referring Martin's type to *F. plebia* McCoy.

Genus Ptylopora, McCoy.

Zoarium, a feather-like arrangement, having a central stem, which gives off lateral branches, which are connected by dissepiments; the branches very rarely bifurcate.

5. Ptylopora Phillipsia. sp. nov.

Zoarium multiform.—Central stem bearing two rows of cells like the *Glauconome* species. Lateral branches striking off at acute angles from the main stem, are united by dissepiments, ultimately forming a cone-like zoarium. Zoœcia on the central stem, one between each of the branches, on the branches from two to three on each side of the fenestrule. Dissepiments strong, slightly dilated at the points of junction with the branches.

Locality: Castleton, Derbyshire. Rather abundant.

The peculiar habit of this species is so unique that I feel certain that it is not the *Ptylopora pluma* of McCoy. I have some doubts as to whether fragments of the cone-like zoarium have not been

previously referred to *F. membranacea* as some resemblance exists between the two species if the central stem is absent in the fragment: otherwise there are few features in common between *Fenestella* and *Ptylopora*. The fragment named *Retepora pluma* by Phillips, must not be confounded with *Ptylopora pluma* McCoy. I have a specimen of the latter species from Malahide, and the species is very well figured in *Nicholson's Manual of Palæontology*, Vol. I., p. 423. Sometimes the fossil here described is present in the Limestone as casts only, it is then seen that the place in the zoarium which the central stem occupied is a long and central furrow, and the surrounding cast has some resemblance to a minute auger, and when seen for the first time, is likely to be a complete puzzle to the palæontologist. As the genus is a rare one, these minute particulars may be the means of drawing the attention of the student to special features, such as the apex and the base, which are not so well known.

6. Ptylopora pluma? McCoy. (Compare with Figs. 263, p. 422, *Manual of Palæontology, Nich.* vol I., with Fig. 9, p. 14, *Page's Introductory Text Book of Geology).*

I am not certain that this is really the *P. pluma* of McCoy, as the only portions of the Zoarium that I have are the central stem with some of the lateral branches. Accepting Nicholson's fig. as above I will now describe the fragments. Central stem (Glauconome like), the origin of the stem appears as a root-like prolongation divided into narrow prongs altogether unlike the stem in its after development; higher up rootlets appear on the sides, and higher still the normal character with lateral oblique fenestrations as in ordinary *Ptylopora*. Normal stem with a broad central rounded keel bearing in the sides a row of cells, alternately placed on either side of the keel—keel spinulose along the centre. Branches united by dissepiments which are rather broad in the junction; apparently destitute of keel. Fenestrules rather broad, slightly oval bearing on either side three cells,—openings circular. General shape and size of Zoarium unknown.

Locality.—Castlelon, Derbyshire.

There is a marked difference between this and *P. Phillipsia.*

1st.—The root-like base of the present species is, so far as I can see, unique. 2nd.—The strong rounded central keel with its spiniferous row is also different, in *P. Phillipsi* there is no prominent keel, the two rows of cells are in one plane, and whenever these are exposed, the bases of the cells are contiguous as in *Glauconome* species. I have purposely kept the two distinct, but the possession of better material may cause me to alter my opinion in the future. Under present circumstances it is impossible to do so.

Genus POLYPORA, McCoy.

7. POLYPORA LAXA, Phill., *Geol. York.*, Vol. I., pl. I., figs. 26-30. (*Retepora laxa*, pars.)

= *Fenestella laxa*, Phill. Palæoz., Foss. of Devon, Cornwall, &c.

= *Polypora laxa*, Morris, Cat. Brit. Foss.

"An irregular open network, interstices round, bearing on the reverse, oval spaces in quincunx, and interjacent lines of very minute pores. It resembles *Gorgonia ripisteria* Goldfuss." Such is Phillips' original description of *Retepora laxa* of Whitewell; but the description is far more applicable to the Derbyshire, than to the Yorkshire specimen. In the Palæozoic fossils of Devon, &c., Phillips referred a similar fossil to his Yorkshire species. In his Geology of Yorkshire, Phillips seems to have given figures of two different species, but I cannot make out distinctly what they are. I cannot believe that Phillips was entirely ignorant of the Derbyshire specimens, for his larger figures closely resembles that which is before me. I shall therefore describe the Derbyshire species as the nearest to the original of Phillips.

Zoarium, an open network with a very irregular habit. Root like base thick and prominent. *Branches*, round, rather more robust in its early, than in its later stages; bearing three rows of cells on the face, reverse striated. *Fenestrules*, large and irregular, from two to three, in two lines, measured transversely, dissepiments thin.

Localities: Survived from Devonian, Phillips; Carboniferous, Whitewell; Kildare, Ireland; Derbyshire, Castleton; Settle, Yorkshire; Richmond, Yorkshire.

8. POLYPORA TUBERCULATA?

In the general aspect, specimens of the Zoarium of this species, closely resemble the Scotch *Polypora tuberculata* Prout, and I am

not certain that the British species is not identical with it. For the present it may be as well to retain them separate, because there are still some features in the Scotch that I have not as yet detected in the Derbyshire species. The general habit of the two is similar; the arrangement and character of the cells is the same; it is only in the superficial tubercles that there is a difference.

Localities : Castleton, Derbyshire; Settle and Richmond, Yorkshire.

Genus THAMNISCUS, King.

Branches free, round, frequently and regularly bifurcating; more or less in one plane; Zoœcia on one side, cells immersed, round, arranged in oblique lines.

9. THAMNISCUS DUBIUS? King, *Permian Foss.*, p. 44, pl. V. *T. dubius*, (Shrubsole) Paper on *Thamniscus*, *Quart. Jour. Geol. Soc.* August, 1882.

Var. *Carbonarius*, new var.

Zoarium, a series of flattened branches generally in one plane. Branches free, frequently dividing, measuring about half a line in breadth, equal in size along their whole length. *Zoœcia* on one side of the branch, apertures circular arranged in lines, or obliquely; about six cells in one line measured longitudinally, from four to six rows in the width of branch.

Localities: Castleton, Derbyshire; Settle, Yorkshire (small fragments).

There is a very great difference between the above species and that described by Mr. John Young, as occuring in the Carboniferous rocks of Scotland. *Thamniscus? Rankini*, Young (Ann. Mag. Nat. Hist., May 1875), is of uncertain affinities; for as Mr. Young remarks "Meanwhile though strongly disposed to regard this fossil as a true *Hornera*, or a member of a closely allied genus, we think it safer to leave it in the Palæozoic genus *Thamniscus*." The Scotch type may be ultimately placed in the genus *Hornera*; but the present form has not the least affinity with that or any genus related to *Hornera*. I have named the species as a variety of *T. dubius* out of deference to Mr. G. W. Shrubsole, whose paper on *Thamniscus*, Silurian, Carboniferous and Permian (*Quart. Jour. Geol. Soc.*, Aug. 1882), merits this special approval. In that paper the whole history

of King's types is recorded, and a fresh description of *T. dubius* is given, after a careful comparison of the Permian specimens in the Newcastle Museum.

The Derbyshire species is comparatively rare, but I have been singularly fortunate in the fragments given to me by Mr. Aitken. I have both the reverse and the obverse, and besides this, there are several smaller fragments which afford good diagnostic characters. In founding the Genus *Thamniscus* Prof. King says "It embraces the two following genera, one of which *(Thamniscus)* is the type, and apparently Mr. McCoy's *Ichthyorachis. (Permian Foss.* p. 43.*)*

The following is McCoy's description of this genus :—

Genus ICHTHYORACHIS, McCoy.

A straight central stem, having on each side a row of simple branches or pinnæ, all in the same plane, obverse rounded, without keel, *each bearing* several rows of small prominent oval pores, arranged in quincunx, reverse smooth, or finely striated. (Carb. Foss.)

The only species *I. newenhami*, McCoy, County Clare, Ireland.

The type of this genus appears to correspond more closely as an ally of *Glauconome* than *Thamniscus*, yet there are specimens amongst my Derbyshire collections that seem to reconcile the apparent conflict of opinions, but I do not think we shall be able to maintain McCoy's genus as a separate type. I will endeavour to describe fairly the two types and leave the reader to judge.

10. ICHTHYORACHIS, s.p.

Zoarium in its earlier stages, a strong central stem with lateral pinnæ. These do not strike off at right or acute angles like *Glauconome* but the pinnæ bifurcate as free branches, rather diminutive at first, but towards the apex of the branches as bold and unfenestrated twigs. In the earlier stage the cells are arranged on the surface of the stem in three rows, on the pinnæ in two rows, and on the terminal free branches in from two to three rows.

In a small fragment of another, or the true *Thamniscus* type, casts of the main stem remain with a few lateral depressions. A small poriferous portion still remaining in one of the furrows, show that the arrangement of, and character of the cells are similar to the variety already described. In the absence of better material I must

leave the species as somewhat doubtful.

Locality: Castleton, Derbyshire.

Genus GLAUCONOME, Goldfuss.

(See paper by G. R. V. on Carb. Polyzoa, North Yorkshire, Trans. Geol. and Polytech. Soc., 1881).*

If we except *Retepora pluma*, which has yet to be worked out, no *Glauconome* was described by Phillips in his *Geol. of Yorks.* In his *Palæozoic Foss.*, a species which is described as occuring in the Upper Devonian, is named *G. bipinnata*, and McCoy in describing a similar species from the Carboniferous Limestone, Dungannon, furnishes us with a few particulars respecting his type. It appears to me that Phillips' species was founded upon a peculiar habit, if so, this species is not unique in its *bipinnate* arrangements. Mr. John Young, of Glasgow, writing me about English and Irish *Glauconome*, says (Oct. 1877) "We seem to have no *Glauconome* in Scotland answering to the description of *G. grandis*, and *G. gracilis*, McCoy, although both have been noted in former lists from our beds. McCoy states that *G. grandis* has very small round prominent pores, one at the origin at each branch and three between. *G. gracilis* is said to have in each side a row of very large circular prominent pores which strongly indent the margin, one at the origin of each branch and one between, and about half the diameter apart. After very close examination of all our specimens, I have never found a fragment agreeing with either of the above species. I am inclined to think that we have only one species that agrees with any of McCoy's description, that is *G. bipinnata*, Phillips. In the shales from Capelrig we find a form with a straight crenated keel, or midrib, that has an oval pore at each branch and one between, reverse strongly granulated. McCoy does not mention anything about the keel in his description, he only says 'obverse with two rows of approximate oval pores, reverse with strong granulated striæ.' If it can be shown that *G. bipinnata* is not keeled in the typical form from

* In my fourth British Association Report on Fossil Polyzoa, 1883, I have altered—for reasons there given,—the generic name *Glauconome*, for that of *Pinnatopora*. As this paper, however, was written and read before the change was made, I have allowed the references to stand. I reserve the Genus *Glauconome* Goldfuss for Silurian specimens only.

England or Ireland, then the Scotch species is new, but rather than make it such, in the meantime I shall leave it as it is, and distinguish it as *G. bipinnata ?* Phillips." After this letter was written Mr. Young sent me specimens of this species, and I shall use it in making my comparison with the Derbyshire fossil.

11. Glauconome bipinnata? Phillips. Palæozoic Fossils of Devon, &c.

Zoarium, a long stem which branches rather acutely at distances about four lines apart; in the intervals of the larger branches, smaller pinnæ, four to a line, are placed alternately on each side of the main stem. *Zoœcia* on the main stem, orifices oval, two in the intervals of the small pinnæ, or about eight to a line on each side of a not very prominent mid-rib; cells on the branches similar to the main stem; cells on the pinnæ rather smaller, and more closely set. Reverse striated, or slightly granulated.

Localities: Upper Devonian, Pilton, Croyd; Castleton, Derbyshire; Ireland, (McCoy), Blantyre ? and Capelrig ? Scotland. The *Glauconome* of Settle, Yorkshire, is not in a sufficiently good state of preservation to allow me to describe the species.

In the Carboniferous Limestone of Derbyshire there are several varieties of this peculiar type, one of which possesses a very strong main stem, pinnate and bi-pinnate as already described. I cannot, however, regard it as a distinct species, the only additional character is its robustness. The arrangement of the cells are similar. I can only suppose that this additional feature is the result of age.

A reference to my former paper will show directly, the difference between the character and abundance of Glauconome in North Yorkshire and in Derbyshire. For a long time I regarded the *Retepora pluma* of Phillips *(Geol. York.* pl. I., fig. 14-15) as a *Glauconome*, but the careful working of the type seems to dispel this idea. In all probability fig. 13, pl. I., *Geol. York.* is the reverse of *G. bipinnata ?* Phillips, but it is hard to say.

Genus Rhabdomeson, Young.

Ann. Mag. Nat. Hist., January, 1874.

12. Rhabdomeson gracilis, Phillips sp. Palæozoic Fossils, Devon, &c. (See North Yorkshire Polyzoa by G. R. V, Trans. op. cit).

I have only detected a few fragments of this species in the Derbyshire Limestone specimens. The species has a very wide range.

Localities: Devonian. Pilton (Phillips), Castleton; Hurst, Richmond, Yorkshire; Scotland, very generally distributed; Northumberland.

There are still remaining a few doubtful species, in my own, and in Mr. Aitken's collection. I cannot work these into the present paper for they are without a local habitation, and the fragments are not in such a state of preservation as to allow me to do them justice.

Now that attention has been directed to the Polyzoa of Derbyshire and North Yorkshire it is to be hoped that in the coming season for geological excursions some little attention will be given to the presence of these as well as to other, probably, more attractive groups of fossil remains.

ON THE GEOLOGY OF PALESTINE. BY W. H. HUDLESTON, M.A., F.G.S., &c.

In the original choice of the subject, two principal considerations influenced me. In the first place, there is no foreign country whose history and geography attract more attention from all classes than does the Holy Land. It seemed therefore certain that a previous geographical acquaintance with the region might induce some curiosity as to its geological structure. And this brings me to the second consideration, which influenced my choice of a subject, viz., that Palestine—using the term in its widest geographical sense—contains within its borders some of the most remarkable features on the surface of the earth; and, notably, that astounding fissure, the Dead Sea Basin, which probably has exercised the imagination of most of us for a long period, and which geology, of all the sciences, is the most competent to investigate.

To facilitate reference, the subject has been divided into eight sections, as follows:—

1.—History of the Investigation of the Region.
2.—Physical Geography.
3.—Geological Outline and Explanation of the Map.
4.—Beds older than the Cretacous Limestone.
5.—The Cretacous and Nummulitic Limestones.
6.—Post-nummulitic (Marine) Beds.
7.—Volcanic Rocks.
8.—Deposits of the Dead Sea Basin.

1. *History of the investigation of the Region.*—This branch of the enquiry is by no means devoid of interest, and might almost form a subject of itself, independent of the others. Of course we could go back as far as the days of the Crusades, for even then the fossil fish of the Lebanon were not unknown, since Richard Cœur de Lion is said to have noticed them; but for our purpose it will suffice to begin with the present century.

What we must now term the first occupation of Egypt by the British forces, in the early part of the present century, drew particular attention to the East, but such was the disturbed state of affairs during the period of the revolutionary wars that travelling was for the most part suspended, though some of the Royal Engineers about this time made short surveys in portions of Palestine. It is evident, however, that the occupation of Egypt had drawn attention to the East, for there was a meeting held of the *Palestine Association*, as it was then called, on the 24th of April, 1805. What they did is not known to me, though there is a tradition that agents were sent out, who got no further than Malta. Anyhow no active steps were taken by this body after the year 1809, and the Association may be deemed to have led a suspended existence up to 28th January, 1834, when a meeting was called, Mr. Bartle Frere in the chair, which resulted in the balance of its funds, amounting to £135 9s. 8d., being handed over to the *Royal Geographical Society*, and the original *Palestine Association* was, I presume, thenceforth regarded as defunct. But this is anticipating: we must now revert to an earlier date. At the close of the great war there was an immense increase of travelling all over the world, and the East very naturally came in for its share. Some of you are perhaps acquainted with the interesting narrative of Irby and Mangles, and with the classical work of Burkhardt, which, together with others published before 1830, laid the foundation of our physical knowledge of Sinai and Palestine.

Geology in those days was quite in its infancy, yet Burkhardt had an eye in that direction. But the first really geological work was one by Botta, entitled *Observations on Lebanon and Anti-Lebanon*, published in the Memoirs of the Geological Society of France, in

the year 1833. So that France led the way to geological research in Syria, and that lead she has since fully maintained.

I must now say a word about an important discovery. This was no less than a recognition of the singular physical fact, that the Dead Sea Basin, for a length of 200 miles, lies at a considerable depth below the level of the sea. Not only were the writers of antiquity ignorant of this peculiar feature, but it had also escaped the notice of Burkhardt and the earlier travellers, so that five and forty years ago, the whole world, scientific and unscientific, were quite ignorant of it. Like many great discoveries, it seems to have dawned upon several people nearly about the same time. It is not easy to assign the credit of the first discovery, but in the year 1837, two Englishmen, Messrs. Moore and Beck, published an account in the journal of the *Royal Geographical Society*. There was a considerable difference then and subsequently, as to the actual amount of the depression,—but to anticipate, I may say that the Surveyors of the *Palestine Exploration Fund* have fixed the level of the Dead Sea surface at 1,292ft. That was a time of general activity in the way of Palestine research, as the well-known work of Dr. Robinson appeared in the following year,—viz. in 1838,—and it was at this period also, that the Austrian mining engineer, Russegger, travelled, though his work was not published until ten years afterwards.

Encouraged by the success of their learned fellow-countryman, Dr. Robinson, the Americans entered into the investigation with great zeal, and the decade between 1840 and 1850 witnessed some important contributions from them. American missionaries have generally been observant men; some of them in Syria had made certain notes and collections of specimens, and these were submitted to Professor Hitchcock, who wrote a most important paper, so valuable indeed, that M. Lartet says, that Hitchcock, although never there, had a far better idea of the geology of Palestine than the majority of travellers, whether before or since his time; but then Hitchcock is a geologist, whilst the majority of travellers are not.

The efforts of the Americans culminated in the expedition undertaken by Lt. Lynch, in 1848, with Dr. Anderson as geologist. The party launched a couple of metal boats on the Lake of Tiberias,

and after an exciting and hazardous voyage down the Jordan, reached the Dead Sea in safety. Considerable difficulties were experienced, owing to the shallows, and to the tortuous character of the river, which describes a course of 200 miles, when the actual distance is 65 in a straight line. The Jordan was probably then navigated for the first time, though the *Rob Roy* canoe afterwards, I believe, ventured upon its waters. A very efficient investigation of the Dead Sea was made, and the leading physical features of the great fissure, known as the Ghor, ascertained beyond question. It was at the same time proved that even the weird and unwholesome nature of the place, in addition to Arab troubles, could not prevent a well-led and devoted party from doing its work effectually. Lynch's men were, I believe, all total abstainers. A large collection of fossils was made by Dr. Anderson, and many of these were described and figured in the fine quarto which recorded the results of the expedition.

After this adventurous journey there was a lull for some time in Palestine exploration: the cream of the mystery had been solved, though as yet but little real progress had been made in geology. But in the next decade renewed attention was paid to the subject, and two works appeared, which may be said to have placed the geology of Palestine on a firm basis. These were *Aus dem Orient*, by Dr. Oscar Fraas, and *La Géologie de la Palestine* by M. Louis Lartet. These authors have published other works on the subject, but I mention the above, as being amongst their most important contributions. Lartet's book was the outcome of his experiences as geologist to the celebrated expedition of the *Duc de Luynes*, undertaken in 1864, and which has been more fruitful in geological information than any other. The party commenced their investigations in the Lebanon, and thence passed by way of Samaria and Galilee to Jerusalem; then on to the Dead Sea, where they embarked on board the iron vessel, *Ségor*. Their examination of the Dead Sea was most thorough, methods being adopted for obtaining the water from various depths for analysis, anticipating as it seems in some respects those used by the *Challenger*. The party then ascended the right bank of the Jordan, about half-

way to the Lake of Tiberias, returning by the left bank, and so along the east side of the Dead Sea, through the mountains of Ammon and of Moab, which they were the first to examine from a scientific point of view. A second visit was made to Jerusalem, whence they again started by way of the mountains of Judæa for the Dead Sea, and so up the Wady Arabah into the Petra district, and thence over the watershed between the Wadies Arabah and Akabah, and down to the head of the gulf. It may be safely said that no observer ever brought away with him such an important mass of geological information respecting these difficult countries as did M. Lartet. In fact, it would be needless to say more of this particular journey at present, as the results form the basis of this communication.

About the same period, some good work was done rather outside the Palestine area, and chiefly in the Sinai district, by some of our own fellow-countrymen. I would especially mention the papers by Messrs. Duncan, Carter and Holland, in the *Quarterly Journal of the Geological Society*, and very important papers by Mr. Bauerman and Professor J. Milne. Mr. Bauerman's paper is by far the most valuable contribution we possess relative to the mining districts of the Sinai Peninsula.

We now come to the *Palestine Exploration Fund*, which was founded in 1865, "for the purpose of elucidating and illustrating the Bible, by a systematic survey of the Holy Land, by excavations, by the collection of traditions, manners and customs of the people, and by researches into the natural history, meteorology, and geology of the country." In the *Quarterly Statement* for 1869, it is remarked "Of this (*i.e.* of geology) we are in ignorance in almost every detail; the valley of the Jordan (and basin of the Dead Sea) is geologically one of the most remarkable on the earth's surface."

It is impossible to speak too highly of the topographical work of the survey, but somehow, very little geological work has been done, though there are papers by Captain Conder, which show that the subject possessed considerable attraction for him. His Physical description of the Holy Land,* and his chapter on the Jordan

* Tent Work in Palestine.

GEOLOGICAL SKETCH MAP
of
SINAI & PALESTINE,
(based chiefly upon M Lartet's maps)

N.B The figures represent elevations above the sea level in English feet: those with a minus mark represent depressions below sea level.

To illustrate Mr Hudleston's paper.

STATUTE MILES.
0 50 100 150

Mintern Bros, lith

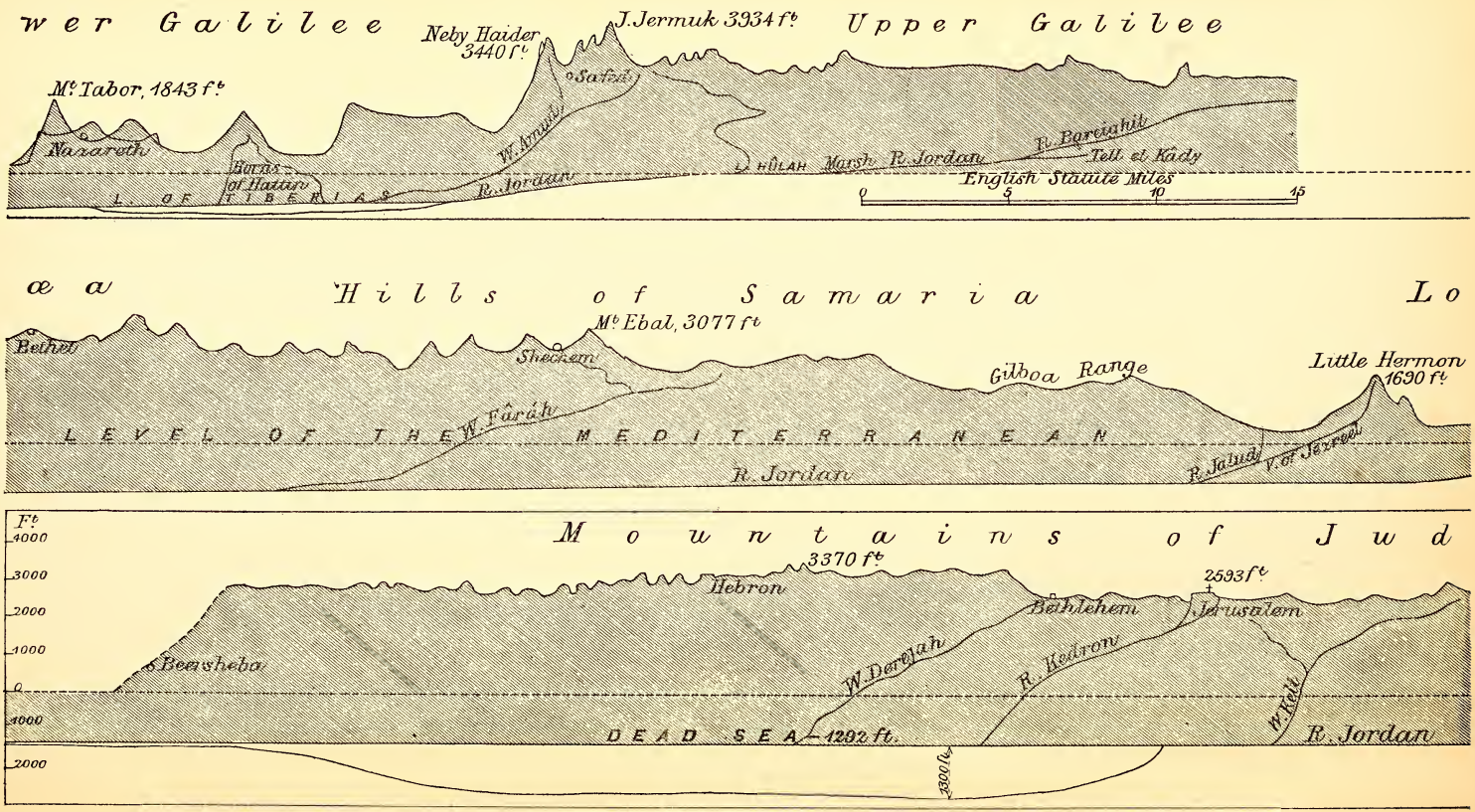
valley,* should be read by everyone desirous of becoming acquainted with the geognosy of these regions. The one-inch map of Western Palestine was published by the Committee of the *Exploration Fund*, in 1880, and there is a very useful reduction, together with sections executed by Mr. Trelawney Saunders. Fig. 1 is a reduction from a meridional section constructed by him. I ought to mention here also the Ordnance Survey of the Peninsula of Sinai, undertaken in 1868–9, of which a most interesting account is given by the late Professor Palmer, in the first volume of the *Desert of the Exodus*.

Though scarcely geological, the admirable volume of the late Dean Stanley, and the adventurous narratives of Canon Tristram contain much geognostic information, and as they are well illustrated and ably and pleasantly written, these works have always been in great favour with the English public. In concluding this part of the subject, I may remark that as far back as the year 1867, no less than eighteen hundred and sixty works were enumerated on the subject of Palestine, and they have increased portentously since then. It is true, that very few of these contain the smallest item of geological information, yet much has to be read in order to pick up the scanty morsels. The importance of M. Lartet's works cannot be over-estimated.

2. *Physical Geography.*—It will be necessary to consider the geography before attacking the geology. According to Captain Conder, the limits originally assigned by Moses to the Holy Land extended from Mount Hor on the *south*, to the water-parting of the two great Lebanon rivers, Orontes and Leontes, on the *north;* and from the Mediterranean on the *west;* in the direction of the Euphrates on the *east*. For our proposes we must exceed these limits on the south, so as to include the whole of the peninsula of Sinai. Without attempting to give it a general name, we shall take into consideration the whole country, from, say Baalbec, which is very near the aforesaid water-parting, to the most southerly part of the peninsula of Sinai; the western boundary will be the Gulf of Suez, and the line of the canal; the eastern boundary stretches towards

* Hand Book to the Bible.

Fig. 1. Meridional Section of Western Palestine. (Reduced from Mr. Trelawney Saunders' section by W.H.H.)



the Arabian desert.

In order to give some idea of distances, and by consequence of relative size, let us commence at the foot of Mount Hermon, which must be regarded as the parent of the Jordan, and the great condenser of moisture in those regions.

	MILES.
Foot of Hermon to the Lake of Tiberias	28
Lake of Tiberias, length	12
Jordan Valley...	65
Dead Sea, length	46
Dead Sea to Gulf of Akabah	114
Head of Gulf of Akabah to Jebel Mousa	105
	370

Again, the width of lower Galilee, from Acre to the Lake of Tiberias is about thirty miles, whilst the width of Judæa from the Mediterranean to the Dead Sea is about fifty miles.

Palestine, as we usually understand it, is an upland plateau, split longitudinally by the *crevasse* of the Dead Sea Basin, and it lies between the great limestone ranges of Lebanon and Anti-Lebanon (including Hermon) on the north, and the almost equally lofty granitic ranges of Sinai on the south. Lebanon and Anti-Lebanon roll over in a series of convolutions, but nowhere, according to recent survey, is there so high a point as Hermon, which must be regarded as the monarch of the region, with an elevation of 9,200ft. Hermon is the southern termination of the range of Anti-Lebanon, and looks down upon the mountains of upper Galilee, which barely attain to half its elevation. The volcanic mass of Jebel Kuleib, the hill of Bashan, attains an elevation of 5,600ft., but south of this, there are not many points over 3,000ft. on either side of the Jordan, till we come to Mount Hor, 4,360ft. Between this and the gulf of Akabah, are some lofty hills, one of which is the Sinai of Dr. Beke. There is one feature to which I would particularly draw attention, and that is to the very considerable watershed which exists between the Wady Arabah and the Wady Akabah.

The country west of the Wady Arabah is usually known as the Negeb, or south country, and was part of the "Land of Promise;" south of this again is a most terrible country known as the Desert

of the Tih, a limestone plateau, whose central point is marked in the maps as 1,480ft This is about half way between Suez and Akabah, and is the place for which the late Professor Palmer was making when he was murdered.

A remarkable limestone escarpment forms the termination of the desert of the Tih, wedging itself into the Sinai Peninsula. The Negeb or south country, wedges itself into the Tih in a similar manner. In the Sinai Peninsula the mountains again become very lofty, and there are three granite ranges which especially claim attention: on the west is Jebel Serbal; in the centre is the Sinai group, culminating in Jebel Katarina, the highest peak in the peninsula, 8,536ft.; on the south is the peak of Um Shomer, for a long time regarded as the highest of all. These lofty mountains of the Sinai Peninsula constitute the central section of the tripartite granitic region, which is severed by the gulfs of Suez and of Akabah.

Let us now direct our attention to the topography of western Palestine, since this has been surveyed with great accuracy (see Figure 1) which affords a meridional section of the whole country, I might say, from Dan unto Beersheba. In this section the upper sinuous line represents the watershed of western Palestine, between the Mediterranean and the Jordan valley; the middle line represented the level of the Mediterranean, and the lower line the course of the river Jordan. In sections of this kind the difference between the vertical and horizontal scales produces a false estimate of the abruptness of the slopes. Bearing this in mind, the section is an instructive one, though perhaps it requires a little reflection to understand.

The great basaltic mountains near Safed attain an elevation, as I before said, about half the height of Hermon: north-east of this great mass, lies the basin of the Hûleh marshes, which may be regarded as the *first* section of the Jordan valley system. In this marshy hollow the four rivers which form the Jordan unite, and open out into the waters of Merom or Lake Hûleh, whose surface may be regarded as nearly on a level with the Mediterranean. The great drop in the chasm of the Jordan valley occurs between Lake Hûleh and the lake of Tiberias, the fall being at the rate of 68ft.

per mile. This fall takes place between the volcanic masses of Safed and the Jaulan.

The *second* section of the valley includes the basin of the Lake of Tiberias, twelve and a half miles long, eight miles wide, and one hundred and fifty feet deep. There is a very great lessening in the height of the watershed opposite this basin, as though Lower Galilee had been let down bodily. The hills, though famous in history are amongst the most moderate elevations of the country.

The *third* section includes the gorge of the Kaukab, opposite Mount Tabor and Little Hermon, where there is another sharp drop.

The *fourth* section includes the Plain of Beisan, which connects by way of the Vale of Jezreel with the Plain of Esdraelon over a watershed, which cannot exceed 300ft., and which is therefore considerably lower than the watershed between the Wadies Arabah and Akabah. Indeed if the whole country were lowered between 300 and 400ft., perhaps rather less, the waters of the Mediterranean would flow into the great depression of the Dead Sea basin and fill it up, leaving still 300ft. before those of the Red Sea could meet them. The Vale of Jezreel is probably one of the most desirable and well-watered portions of the country, and fertile, like the Vale of Esdraelon, on the other side of the watershed. It might be tedious to detail the remaining four sections into which Captain Conder divides the Jordan valley. I will merely point out that it receives a considerable affluent from the west in the perennial stream that flows down the Wady Fârâh, which, there is reason to think, may follow the line of some important dislocation, and, at all events marks a great change in the character of the country. The Wady Kelt flows into the Jordan through the Plain of Jericho, and there are many salt springs throughout this part of its course.

The shape of the basin of the Dead Sea may be gathered from the section. (Fig. 1). An extreme depth of 1,300ft. is marked, though this is a little in excess of any on M. Lartet's map. The southern end is quite shallow for many miles, so that the actual basin of the Dead Sea now occupied by deep water is less than one would suppose.

I would direct your attention for a moment to the watershed

which, if you were to trace it on the map, is pretty nearly equidistant, sometimes inclining towards the Mediterranean and sometimes towards the Jordan. It is not a little singular, how many places of interest are situated on, or close to the watershed—Nazareth, Shechem, Bethel, Jerusalem, Bethlehem, Hebron, illustrate the fact. Leaving the plains and moderate hills of Lower Galilee, we rise through the hills of Samaria to the Mountains of Judæa, and as over 1,000ft. has to be added to their height above the sea, the Mountains of Judæa show a massive section on the east side, the brow of the cliff or escarpment, overhanging the Dead Sea, being something like 2,000ft. above the great depression.

Now this great mountain group of Judæa is a natural fortress, and has been held for ages by a proud and determined race of highlanders, who had great contempt and hatred for such lowlanders as the Philistines. In after times the plateau was held by Saladin, whilst Richard overran the lowland plains. The plateau of limestone resembles very much the limestone pavements of Craven.

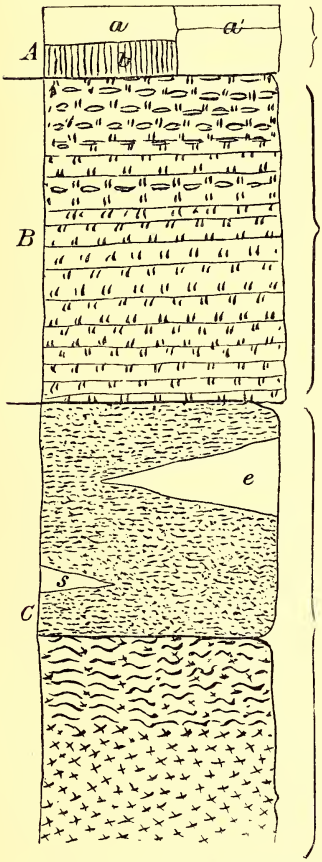
The physical geography of western Palestine would be incomplete without a word about the maritime plains. There is a strip of low sandy land all along the Mediterranean shore. In Phenicia, this is very narrow, and sometimes cut off altogether, as where the ladder of Tyre protrudes into the sea, and also where the still more conspicuous Mount Carmel makes a solid headland, the highest part of the block being 1,700ft. The Plain of Esdraelon is an inland plain, averaging between 200 and 300ft. in elevation, and covered with a rich basaltic loam; we have already seen that this is on a line of sinking in connection with the Vale of Jezreel. By all accounts, it is the most fruitful district in Palestine.

South of Carmel, along the coast, the maritime plain gradually widens, until the plain of Sharon merges into the wide expanse of Philistia. This is continued all the way to El-Arish, on the River of Egypt, though the boundary of Palestine proper may perhaps be regarded as on the Beersheba stream. In this portion of the maritime plain, Nile mud mingles with the drift sand, and further inland much of this is covered by the *debris* from the mountains. The dimensions are, 80 miles long, and near Gaza, 20 miles wide; 100–200ft. high.

3. *Explanation of the Map and Geological Column.*—"Geological Sketch Map of Sinai and Palestine." (Plate VI).

We must now turn our attention to the geology of the district, and by way of preface, I will give a brief geological demonstration of the map and vertical column (Fig. 2).

FIG. 2.



A.—(*a*) Coast deposits of probably quaternary age; (*a'*) Jordan valley deposits of two kinds; (*b*)? Miocene.

B.—Nummulitic and Cretaceous Limestones and Marls.

C.—The upper portion denotes the Nubian Sandstone, which is made to include the *Glandarius*-limestone and Jurassic rocks of the Lebanon (*e* of the map and vertical section); as also the limestone with carboniferous fossils of the Wady Nasb in the Sinaitic peninsula (*s* of the vertical section).

The lower portion includes the Schists, Gneiss, and Granite.

The use of a vertical column in geology is very considerable, as it enables people to see at a glance what they have to expect. At the same time it must be understood that no such section as is exhibited by this generalized column is ever seen in one place. In the map the *crystalline rocks* are all placed under the symbol *f*, and

this includes the schists, gneiss and granite, which form the nucleus of three mountainous masses, viz.: the Arabian chain (in Egypt), the Sinai Peninsula, and the mainland of Arabia. The crystalline rocks are continued in the Mount Seir range, and probably re-appear in the ancient porphyry of Mount Hor. It is quite possible that these three granitic areas may have formed one continuous mass, as doubtless they still do beneath the surface. At present, as probably for many ages past, they are separated by that curious bifurcation of the Red Sea, which produces the broad and shallow Gulf of Suez, and the deep and narrow Gulf of Akabah.

The next formation, or rather group of formations, is the *Nubian Sandstone,* which has an extensive development in connection with the granitic centres, from whose degradation it has in times past been largely derived. It is most extensively developed in the north of the Sinai Peninsula, where the upland plain of Ramlah is interposed between the chalky desert of the Tih, and the rugged mountains of Sinai. Thence it may be traced all along the east side of the Arabah, through Petra, to the eastern cliffs of the Dead Sea, and even up to the Jordan valley, half way to the Jabbok, where it disappears and is not seen again until we arrive at the great hollow between Lebanon and Anti-Lebanon, which is a continuation of the Jordan depression.

The age of the Nubian Sandstone as a formation, is a difficulty which we shall appreciate in coming to study it in detail. Meantime, for us, it represents everything between the crystalline schists, and the Cretaceous beds. The meaning of these two wedge-shaped masses, *s* and *e*, in the vertical section, Fig. 2, I will explain presently. Now consider for a moment what a variety of rocks there are in our own country, between the crystalline schists and the base of the chalk. There is the Cambrian, Silurian, Devonian, Carboniferous, Permian, Triassic, Jurassic and Neocomian. This shows the fundamental difference between the geology of England and of Palestine. Can the Nubian Sandstone represent all these? Surely not,—yet it may well represent more than one of the great systems in time.

Next in order and far more extensive are the *Cretaceous* and *Nummulitic Limestones,* which occupy such a large area in the map,

and constitute indeed, the entire mass of the Palestine hills, of the Negeb, or south country, and of the terrible desert of the Tih. They are classed together, because of their physical unity, as one great calcareo-siliceous formation. Indeed the only test of difference is the presence of true nummulites. Now there can be no doubt that in Egypt, large portions of the area coloured blue on the map are nummulitic limestones; and also that a considerable portion of the western escarpment of the Tih is nummulitic chalk with flints; there is also a limited area near the head of Wady Akabah. The only localities known to yield nummulites in Palestine proper are the Mountains Ebal and Gerizim, in Samaria; and Mount Carmel, on the coast. There is also a small exposure of nummulitic limestone in Phenicia. Beds of Cretaceous age are largely developed in the Lebanon.

With respect to the portion of the map and section described as Miocene, there is some doubt. All the evidence goes to show that beds usually called "Miocene," were cut through in the southern portion of the Suez Canal, but how far these extend is by no means clear. Of course no great accuracy is claimed for the map in this respect. There is a quantity of flint breccia, the result of the breaking up of the Nummulo-cretaceous series, scattered about in different parts; some of which may be of Miocene age. In one place, near the Gulf of Suez, this was found to be associated with corals of a Miocene type.

The Deposits of the Dead Sea Basin include everything in the long fissure from the foot of Hermon to beyond the roots of Mount Hor. All we can say of them is that they are post-nummulitic, and the same may also be said as regards the *Lavas*, which are so abundant in the north.

The Coast deposits, marked *a*, are regarded for the most part as Quaternary and Recent; they are said to contain shell limestones, much used for building the cities on the Mediterranean; the shells being all those of recent species.

Since the Cretaceous limestones are by far the most important rocks in the country, they have a section to themselves, No. 5. The whole of the rocks below them are detailed under section 4, and those above them in section 6.

4. *Rocks older than the Cretaceous Limestones.*—We must of course begin with the crystalline rocks, of which granite is the most important, but with it are associated those porphyries, which in the Egyptian granitic region have yielded such fine building stones.

The mountainous core of the Sinai Peninsula, including all the great ranges before mentioned, consist of some variety of granite, and it is evident that red felspar granites are the most abundant, and characterize the region by the colour which they impart to the rocks. We obtain our best account of the physical aspect of this region, and of the peculiar features produced by granite and its associated rocks from the pen of the late Professor Palmer.*

This lamented author ascended most of the principal granite mountains, such as Jebel Mousa, Jebel Katherina, &c., and brought away specimens of the rocks; some of which by the kindness of Professor Bonney I have been able to inspect.

Rock Specimen 1.—Let us begin with the summit of Jebel Katherina. This is a *syenitic granite* of a peculiar nature: in a pinkish felspar base, which occupies the bulk of the mass, are small crystals of orthoclase, quartz, and hornblende. The quartz is not insterstial as in the more typical granites.

Rock Specimen 2.—Jebel Musa. This is from Mount Sinai itself, and is a mixture of coarse red felspar and grey vitreous quartz. There is very little trace of any third mineral, so that the rock nearly approaches a pegmatite.

Rock Specimen 3.—Summit of Serbal. This is a more thorough pegmatite than the other, and in better condition; the felspar is a bright red. The two last specimens are very typical of the granites of the Sinai Peninsula.

Serbal is especially remarkable for the number of diorite dykes which traverse the softer granite, and project like so many teeth, according to Dr. Fraas, from the ridge forming the summit of the mountain. The serrated aspect which one sees in pictures may be due to this cause.

We obtain a considerable amount of information relative to the granites of this region from Professor Milne, who accompanied the

* Desert of the Exodus, vol. I., p. 27.

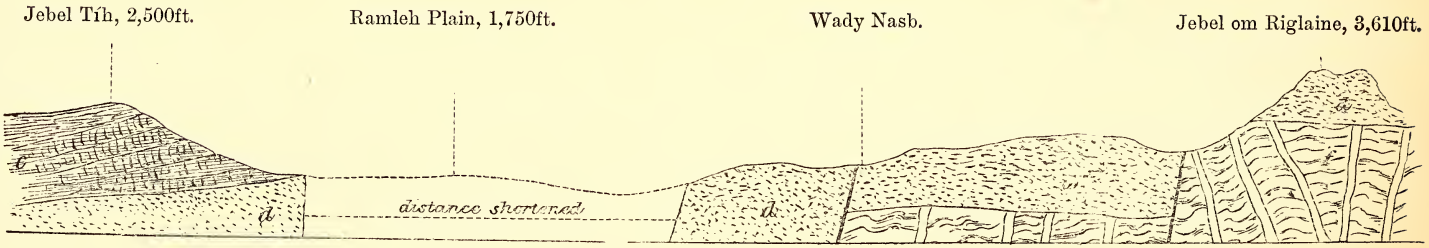
late Dr. Beke in search of the true Sinai. They avoided Jebel Musa, and the whole region of the traditional Sinai, and proceeded to the head of the Gulf of Akabah, where Dr. Beke fully expected to find the volcano from which, according to him, the law was delivered. This supposed volcano is situated a few miles to the north-east of Fort Akabah, and turned out to be a granite mountain, of which Professor Milne gives a good description. The rock was found to be very prone to disintegration, but the dykes which traverse it decay still more rapidly.* From Professor Milne also, we have testimony to the predominance of the felspathic element in the granites and the dykes by which they are traversed. Of seventy two specimens examined, only two approached syenite. It is probable that these observations apply mainly to rocks collected near the gulf of Akabah.

Leaving the crystalline rocks, we now find ourselves face to face with that difficult problem of the *Nubian Sandstone*. The relations of the Nubian Sandstone to the crystalline rocks are well shown in Mr. Bauerman's (Fig. 3) section. This may be regarded as the first stratigraphical aspect of the Nubian Sandstone. As we follow its long exposure on the east side of the Arabah, no base is seen,—this is the second stratigraphical aspect. Then it disappears, and its representative in the Lebanon rests upon the *Glandarius* limestone, and this probably upon the Jurassic rocks of Hermon. I have endeavoured to show this by inserting the wedge-shaped mass, *e*, into the stratigraphical column.

With the help of Mr. Bauerman, let us examine the Nubian Sandstone of the Wady Nasb, where its base is distinctly seen, so that we know that there is nothing but crystalline rocks underlying it. I need not detail the lithological characters, but the chief point of interest lies in the fact that a thin bed of limestone here occurs in it, which contains undoubted Carboniferous fossils. There was much discussion about this at first, but Mr. Holland subsequently sent better specimens, one of which, *Orthis Michelini*, was in very good

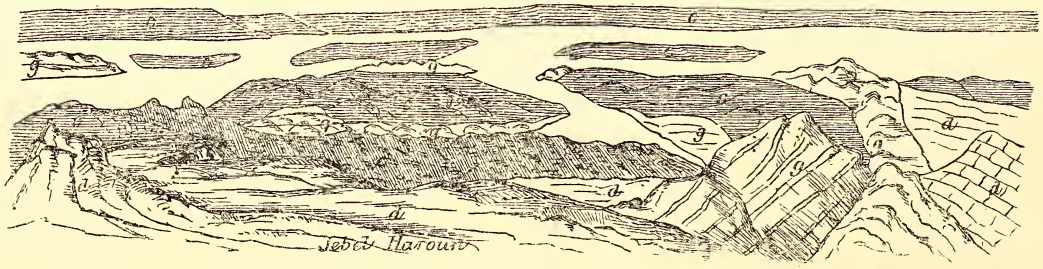
* The episode of Jebel Baghir, or Jebel-el-Nur (the mountain of light), the "true Mount Sinai," first a volcano, then a lightning-haunted peak, is very amusing.

FIG. 3.



c. Cretaceous beds of the Tíh escarpment. *d.* Nubian Sandstone. *f.* Metamorphic schists, porphyries, &c.

FIG. 4.—VIEW OF THE ARABAH FROM MOUNT HOR.



c. Cretaceous. *d.* Nubian Sandstone. *g.* Ancient porphyry of Mount Hor. *x.* Pudding stone.

condition, and Mr. Davidson had no difficulty in determining it. There are other indications that portions of the Nubian Sandstone of the Sinai Peninsula are of the Carboniferous age. There is for instance, in the Museum of the Geological Society, a cast of vegetable impression, marked *Lepidodendron Mosaicum*. Formerly a certain amount of suspicion attached to this fossil, and doubts were thrown upon its being an authentic specimen from the Sinai Desert. It was, I believe, brought to the late Sir Roderick Murchison, and probably received its name from the late Mr. Salter. Since the discoveries of undoubted carboniferous Brachiopoda there seems no reason to doubt the so-called *L. Mosaicum* is a genuine Sinai fossil.

At the base of the Tih escarpment is a fossiliferous deposit containing Cenomanian urchins, &c. There is a strong tendency on the part of both M. Lartet and Dr. Fraas to regard the whole or nearly the whole of the Nubian Sandstone as of Cenomanian age. Dr. Fraas, in his last publication is very decided on this point, and if his statements are to be relied upon, the Carboniferous exposure in the Wady Nasb must present a very exceptional phase.

Let me say a word about the turquoise mines. These occur at Serabit-el-Khadim and other places, in the Wady Nasb district, where they have been worked at intervals of time for ages. This was a great mining country for the ancient Egyptians. The turquoise occurs for the most part in ochreous balls that are situated in certain horizons of the Nubian Sandstone. The best stones are in the solid sandstone, a short distance from the joints. Here again, Mr. Bauerman is at variance with Dr. Fraas, who says, that the turquoise occur in gneiss. The mineral wealth of the sandstone region is very considerable, both iron and copper occuring in abundance. The Arabs were very recently working for turquoise, and have destroyed many inscriptions in these sandstones. Burton, a few years ago, made an expedition into the land of Midian, where the sandstone prevails, and brought away great quantities of minerals.

The last thing to consider is the effect which the Nubian Sandstone has on the scenery of the districts where it prevails. Professor Palmer gives us some capital descriptions.*

* Vol. cit., p. 17.

The *red* of Edom is notorious, but Dean Stanley says that it should be regarded as *dull crimson.* His account of Petra in "Sinai and Palestine," is the most vivid description of Nubian Sandstone known to me.

The summit of Mount Hor, where Aaron died, is composed of Nubian Sandstone. Here is a sketch (Fig.4), taken from "La Géologie de Palestine," which may serve to give an idea of the chaos of rocks in that mountainous region. The masses of porphyry form an important feature. These were formerly supposed to be eruptive, as they seem to come through both the sandstones and Cretaceous limestones. Thus it was held by some that the country had been lifted up by these rocks, and that in this way the watershed between the Wady Arabah and the Wady Akabah had been formed. M. Lartet supposed that these are old eruptive masses, belonging to the crystaline series, and that they must have been there before the deposition of the sedimentary beds. This has an important bearing on questions which will be discussed in section VIII.

The cliffs on the east side of the Dead Sea and the deep gorges of the Arnon and Calirrhöe presents splendid sections of the Nubian Sandstone, where they may be seen underlying the Cretaceous limestones of Moab. The sandstone here has fallen 5,000–6,000ft. below the elevated position it occupies on the summit of Mount Hor. The pages of M. Lartet and of Canon Tristram supply us with most graphic accounts of the extraordinary effect of these cliffs. The gorge of the Calirrhöe is especially remarkable, as there the sides of the deep "cânon" are moulded in black basalt, white limestone, and purple sandstone, the effect of contrast being most marked. Canon Tristram says, that the gorge leading up to Kerak is almost Alpine in its grandeur, and that author considers that there is a decided unconformity between the Nubian Sandstone of that district and the overlying Cretaceous limestones.

Throughout the upper part of the Jordan Valley the Nubian Sandstone is lost sight of, but re-appears in the hollow of Syria. Before noticing its character there, we must consider the beds known to occur in Hermon, which in the stratigraphical column are marked under the letter *e*. These are what are known to the Leb-

anon geologists as the *Glandarius* limestone, which by the testimony of all underlies the so-called Nubian Sandstone of that region. The spines of *Cidaris glandarius* are characteristic of this formation, and have long attracted attention. These were known formerly as "Olives of Sodom," or "Judah stones," though not really found either at Sodom or in Judæa. M. Lartet thought that some portion of the *Glandarius* limestone might be Jurassic, but the Lebanon geologists regard it as of the age of the Upper Greensand: *Syphonia pyriformis*, *Cyphosoma cenomanense*, *Terebratula biplicata* are quoted from it.

The only exposure of undoubted Jurassic rocks occurs on Hermon, where *Rhynchonella lacunosa* has been found on the very summit. There are palæontological indications both of the White and Brown Juras, whilst fossils not uncommon in our Coralline Oolite occur, such as *Ammonites plicatilis* and *Terberatula Maltonensis*, both of which are found in the neighbourhood of Malton. The Brown Jura is represented by Ammonites, such as occur in the Kelloway Rock of Scarborough Castle Hill.

The Lebanon Sandstone is described in considerable detail by Dr. Fraas. The fossils are numerous and leave little doubt as to the Cenomanian age of these beds. Trigonias are very charcteristic, and especially a variety of the group of *Scabra*, one of which is figured in the accompanying plate. There is a considerable amount of contemporaneous igneous rock in these sandstones.

On reviewing the whole question of the Nubian Sandstone, we must admit that the identity of the Lebanon rock with that of the Dead Sea, &c., is not quite so clear as Fraas and Lartet maintain, but in our present state of knowledge we must be content to let the question rest.

5. *The Cretaceous and Nummulitic Limestones.*—The earlier geologists, especially those connected with the Lynch Expedition, believed that there was a considerable development of Jurassic beds, both in the Lebanon and in Palestine proper, and thus many of the fossils are described as Jurassic. There is very little doubt now-a-days that the whole of the calcareous system, with the slight exceptions already made, belongs to the Cretaceous epoch or to yet

newer beds. Hitherto we have met with few traces of fossils, but when we reach an horizon which is represented in N.W. Europe by the zone of *Pecten asper*, *Pygaster lampas*, *Scaphites equalis*, *Ammonites navicularis*, and *Exogyra columba*, there is a great change. This horizon is Cenomanian, and partly corresponds with our Upper Greensand, and it forms the base of the Cretaceous limestones over an immense track of country, extending from S.E. Arabia, and probably even further on the east, to Algeria on the west; so that Palestine forms but a fragment of this extensive area. The deposits of this old sea went on accumulating long after the period when chalk had ceased to be deposited in our own islands, and plainly continued even where Nummulites had become numerous, so that there is no physical break in this great calcareous system. An important change took place in middle Tertiary times, the Cretaceo-nummulitic sediments had become rock, and were subjected to a series of earth movements, such as those which formed the chains of Lebanon and Anti-Lebanon, where this group of beds are folded in undulations which have a general N.N.E. strike. At the same time, the Cretaceous limestones of Palestine were uplifted in the great anticlinal fold, of which Fig. 7 is a cross section. But the complications here are slight compared with those of the northern ranges. It was at this period that the main physical features of the country were written upon it, though the agents of denudation have been carving minor features ever since. We may possibly regard the period of the uplift as Miocene. No marine fossils have ever been deposited since in the area coloured blue on the map, but there are immense deposits of flint conglomerate, gravel and superficial rubbish, which have been accumulating for an immense period of time.

The Cretaceous geology of the Lebanon has been the subject of much study, and of several important memoirs. The first is the memoir by Botta, to which I have already alluded, as the earliest *geological* attempt made in the east; the latest work is the second part of *Aus dem Orient* by Dr. Fraas, published four years ago.

The Lebanon sandstone is credited with the Trigonias already mentioned. Above this comes the Gasteropod zone towards the base

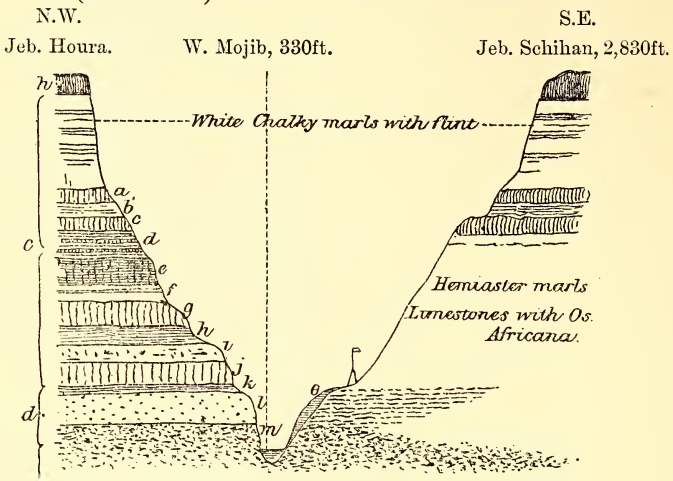
of the Cretaceous Limestones. It contains many species of Nerinæa, two of which are figured in the accompanying plate; next succeeds the zone of *Ammonites syriacus*. Dr. Fraas regards this as Turonian, or what we should call lower chalk, the typical fossil clearly having affinities with *A. rhotomagensis*, and other ammonites found towards the base of the chalk at Lewes. The presence of Hippurites in abundance is another characteristic feature. The upper white chalk-with-flints of the Lebanon Dr. Fraas refers to the Senonian or upper chalk, so that he does not regard it in any way as Tertiary. The remains of the Nummulite beds consequently are rarer in the Lebanon even than in Palestine, but evidently increase in importance as we approach Egypt.

It is impossible to quit the subject of the Cretaeous Beds of Lebanon without saying a word about the fish deposits. These are on two horizons, of which that of Hakel is probably the lower. The fishes are all of those species whose bones are perfect, ganoids being absent. The beds therefore are either Cretaceous or Tertiary, almost certainly the former. There is an enormous collection of these Lebanon fishes at the British Museum, and along with these are some wonderfully well preserved remains of cuttle-fish, &c., one of which Dr. Woodward has lately described in the *Geological Magazine*. Other forms are equally well preserved. The Sâhil Alma deposit is thought to be on a higher horizon, near the white chalk-with-flints, and may possibly correspond with an horizon in Palestine, where M. Lartet detected many remains of fish.

We must now return to Palestine. Not the least valuable and original of M. Lartet's work, was that done in the Cretaceous limestones of Moab, a country always difficult and even dangerous to travel in. He gives us a great number of important sections. I have selected the section across the gorge of the Arnon (Wady Mojib), because it shows the whole body of the Cretaceous limestones from bottom to top, everything in fact, between the Nubian Sandstone and the Basalt.

The complete section is rather over 3,000 feet, and when we have deducted some hundreds for the Nubian sandstone at the bottom, and Basalt at the top, there still remains something like 2,500ft. for

FIG. 5.—SECTION ACROSS THE VALLEY OF THE ARNON (W. MOJIB) EAST OF THE DEAD SEA.



a, Limestones with flint weathering red; *b*, marls with *Pholadomya*; *c*, grey, compact limestones; *d*, alternations of yellow and red chalky marls with tabular limestones containing *Am. Luynesi*; *e*, yellowish limestone with *Ostrea Mermeti*, var. *minor*, and *O. vesicularis*, var. *judaica*; *f*. grey marls with *Hemiaster Fourneli*, *O. olisiponensis*, *Plicatula*, *Pholadomya*, *Venus*; *g*, marly limestones with bivalves and gasteropods; *i*, yellow limestones with *Pterodontes* and other gasteropods; *j*, limestones with *Ostrea flabellata*, *O. africana*, var., *Holectypus Larteti*, *Heterodiadema lybicum*, *Pterodonta elongata*; *k*, green saline marl; *l*, white sandstone; *m*, red sandstone.

the Cretaceous limestones. Three-fourths of this, comprising the beds, form *a* to *j* inclusive, represent the middle and lower chalks of Palestine, not necessarily corresponding with the middle and lower chalk of England, but about that horizon. There are beds of hard and soft alternations, containing a recognized and tolerably abundant fauna.

In western Palestine these middle and lower beds are for the most part seen, as here, in the gorges, though sometimes perhaps brought to the surface of the plateau by synclinal folds. These are the beds which it has so often been the fashion to speak of as Neocomian and Jurassic, but whose very lowest horizon contains a fauna which M. Lartet regards as Cenomanian. The gorge of the Wady Mojib also shows a fine section of the upper white chalk-with-flints,

from which, at another point near Kerak, a remarkable series of fossils was obtained.

In this one section then we have an epitome of the entire series of the Cretaceous limestones of Judæa and of Moab. These are the beds, and especially the upper chalky ones with flint, whose acquaintance the traveller in the Holy Land is most apt to make. Denudation, going on probably ever since the Miocene period, has carved them out in a variety of ways, and the soft upper beds have received much ill treatment. Sometimes everything has been washed away except the flints, which are left in long rows, or as circlets round banks and knolls of the harder rocks. Sometimes the material from these soft upper beds, fills cracks and crevices in the lower and harder ones. Generally one may say that they make a dry soil, and have a tendency to produce a wilderness, such as that of Judah. This kind of thing is probably repeated in the more terrible desert of the Tih, where perhaps there are considerable developments of Nummulitic limestone in addition. All these upper limestones are impregnated with saline matter, and the water from them is both bitter and unclean.

I ought to say a few words about the palæontology of the Cretaceous beds of Palestine. There are two or three noted localities for fossils. One is reported to be near Jerusalem. At any rate numerous Ammonites are found on a certain horizon there, such as French geologists would call Cenomanian.

They belong to a type not unfamiliar to collectors from the lower chalk or chalkmarl, such as *Am. Mantelli*, *Am. rhotomagensis*, *Am. varians*, and along with these are others not known in England, though for the most part related to the same group. The Nerinæan limestone of Jerusalem is celebrated; it will take a good polish, I believe, and I have heard say that the temple of Solomon was in part constructed of this stone. Its excavation has left great galleries in the rocks beneath. The abundance of Nerinæa is noteworthy. At least twelve species are quoted by Lartet, not of course all from the Jerusalem rock; and it is this abundance of Nerinæa which may have induced the older geologists to regard these limestones as Jurassic, since in our country no Nerinæa

is known in beds of later date than the Corallian,* but the presence of the Ammonites named, of Baculites, and especially of Hippurites, leaves no doubt as to the age of these beds.

Amongst the conchifera there are several specimens of Pholadomya. A small but very handsome species is one from the upper chalk of Judæa, figured in the plate. There can be no doubt that it has a tertiary aspect, and reminds one in its deeply chiselled ornaments, of a species figured by Sowerby from the Eocene, I think, of the Isle of Wight. This is probably from Marsaba or Nebi Musa, where there is a well-marked fossiliferous horizon. The most numerous of all the Cretaceous fossils are oysters; these undergo division into several species. The exogyroid forms are related to *Exogyra columba*. The one figured in the accompanying plate is pretty common, and has been identified by Lartet as the oyster of Lisbon *(Ost Olisiponensis)*, described by Sharpe from the Cretaceous beds of Portugal. Sea urchins, especially Hemiasters, are also plentiful.

It remains for me to say a few words about the bituminous deposits of Nebi Musa, which underlie the fossiliferous horizon already mentioned. There is an abundance of bituminous matter in many parts of the Cretaceous series of Palestine, the Lebanon, &c., but this particular place is well-known and often visited, and the black bituminous limestone which it yields is worked up into rosaries and other ornaments by the folks at Bethlehem and Jerusalem. It is known by the name of Dead Sea stone, as the idea of asphalt has always been associated with that lake. The bed of Nebi Musa, however, is a couple of thousand feet above the level of the Dead Sea, and several miles away from it. The limestone, according to Hitchcocks report, contains 25 p.c. of bitumen, and would be valuable as an article for producing asphalt. It is worthy of remark, that just below the chief deposit of bitumen, is a bed full of fish remains. Now, organic matter is the source of all bitumen, which is nothing more than a partially oxidized hydrocarbon with certain impurities;

* Mr. Walter Keeping, curator of the York Museum, has lately described and figured a very peculiar *Nerinæa* from the Lower Greensand of Upware. If this is not a *remanié* fossil, it brings the genus down to a much later horizon in our English beds than previously recognized.

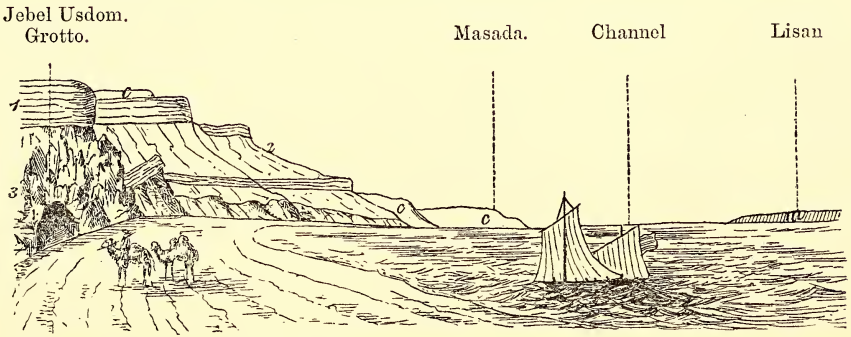
it seems to me not unlikely that the putrifactive decomposition of the animal matter of the fish bed, has yielded the principal part of the bitumen. I may here add, by way of parenthesis, that all fossiliferous limestones are more or less bituminous. When a hot sun falls upon certain portions of the Coralline Oolite of Weymouth, the odour of bitumen is strong, just as in the Wady Mohamet, for example, where, according to Lartet and Tristram, the bitumen actually exudes. The only circumstance which causes me to doubt the animal origin of the Nebi Musa bituminous limestone, is that its odour is described as fragrant, which rather points to a vegetable origin. No doubt most of the Lebanon bitumem is due to destructive distillation of vegetable remains in the Nubian sandstone, and much of the bitumen in former times found floating in the Dead Sea, may arise from bituminized wood in Nubian sandstone on the east side dislodged perhaps, by earthquakes. From this source also, M. Lartet would derive the bitumen of Nebi Musa, volatilized by heat through several thousand feet of beds.

As the subject of sulphur, of which we hear so much in connection with the history of the Dead Sea, is closely related to that of asphalt, reference may be made to a short paper by Dr. Fraas respecting some deposits of sulphur recently observed near Jericho.*

Everybody remembers Lot's wife, and all travellers to the Dead Sea have remarked upon the singular salt deposit in the neighbourhood of which the city of Sodom is supposed to have been located. Fig. 6 is a pictorial section, borrowed from M. Lartet, which may serve to give us some idea of the geological structure of the place. First let me say a few words as to its position. It is a hill, about 5 miles long from N. to S., and a mile broad, which occurs at the S.W. corner of the Dead Sea. This is the shallow south bay of the Dead Sea with the "Sègor" sailing on it; immediately over that vessel is seen the narrow channel between the cliffs of the west coast and the low promontory of the Lisan. These cliffs form part of the great Cretaceous escarpment 2,000 feet high, on which Masada is situated. Perspective causes them to appear so low in the section. On the left of the section is seen the north end of

* *Quarterly Statement, Palestine Exploration Fund*, October, 1880, p. 246.

FIG. 6.—JEBEL USDOM AND THE SOUTH END OF THE DEAD SEA.



1, Gypsum; 2, Saline and Gypseous Clay; 3, Rock Salt; *c*, Cretaceous beds, constituting the cliffs on the west side of the Dead Sea, lowered by perspective; *m*, Old Lacustrine Deposits of the Dead Sea basin.

Jebel Usdom, close at hand and only 400 feet high. This is divided geologically into three portions, the lowest (Fig. 6. [3]) is the rock salt, the thickness of which is variously estimated from 80 to 200 feet. It weathers into numerous pinnacles, some much larger than others, and these pinnacles are Lot's wives. By all accounts it must be rather like a crevassed glacier. Upon this come beds of saline and gypseous clay (Fig. 6 [2]), and in this series are regular beds of gypsum ([1]). The whole is supposed to be surmounted by chalk-with-flint, like any other of the higher Cretaceous beds in the district.

Such is the isolated ridge of Jebel Usdom, and many are the speculations as to its origin. Some have regarded it as an old deposit of the Dead Sea, or rather of its predecessors at a higher level like the deposits of the Lisan, but its structure is very different to these extremely thin-bedded deposits. I will merely say that M. Lartet concludes it to be part of the Cretaceous series, where the saline and gypsiferous element is in excess, and he points out certain horizons, especially in the upper chalky beds, where there is a considerable development of salt and gypsum, though nothing like what occurs here. Lartet says that the position of the hill from a stratigraphical point of view is also favourable to the notion, whilst we have already seen that the limestone series south of Jerusalem to the borders of the Sinai sandstone is throughout so saline that decently potable water is very scarce. Somehow the salt of the old Cretaceo-nummulitic sea has never been fairly washed out of it. We must conclude therefore, for the present, that Jebel Usdom is merely an exceptionally saline development of the Cretaceous rocks which form the principal part of the rim round the basin of the Dead Sea.

Canon Tristram, I may observe, who formerly advocated the notion of these being old Dead Sea deposits brought up by a swelling of the ground, has lately abandoned this idea, and now places Jebel Usdom at the top of the Nubian Sandstone, which he is disposed to regard as "New Red." This seems to me a most gratuitous conjecture, although there may be evidence in the background, which that author does not adduce. This concludes the section relative to the Cretaceous and Nummulitic limestones.

6. *Beds of marine origin, newer than the Nummulitic limestones.*—Beds with Miocene fossils I have already stated as occurring in the Chalouf cutting of the Suez canal, but whether the whole of the district marked *b* in the map, is to be regarded as Miocene is extremely doubtful. Yet the hollow or depression of the Isthmus of Suez, is, in part, filled in by Miocene beds, and it is probable that since Miocene times, there has been no communication between the Red Sea and the Mediterranean, notwithstanding the very slight water shed. It is said that not a single species is common to the Mediterranean and the Red Sea, whose fauna belongs to the Indian Ocean. The Red Sea fauna extends up to the basin in which the Bitter Lakes are situated; and the Mediterranean fauna is traced southward for some distance, but they never meet. A portion of the intervening ground between Lake Timsah and Serapeum is occupied by freshwater beds, which show that a branch of the Nile, most likely in Quaternary times, flowed through the hollow now occupied by the sweet water canal, past Tel-el-Kebir and Ismailia, where it most probably turned round into the Red Sea. The Etherias of the Nile, now confined to the cataract districts and above, are found in abundance in these deposits near Serapeum. Etheria, I may mention, is a peculiar genus of the family Unionidæ, very characteristic of some of the great African rivers.

Most of the coast deposits in the great bight which lies between Mount Carmel and the delta of the Nile, are regarded by Lartet as Quaternary and recent.

7. *The Volcanic Rocks.*—Under this head I would only include the Tertiary eruptions, interpreting the word Tertiary in its widest sense, as coming down to the present time. Mr. Bauerman concluded that the volcanic rocks of that portion of the Sinai peninsula visited by him were of two periods, of which the second was contemporary with the flint conglomerate.

The twenty-eight *harrahs* of Arabia, in alignment with the Red Sea, the Gulf of Akabah, and the Dead Sea hollow, are remarkable instances of the parallelism of volcanic centres to fissures filled with water. I should mention that a *harrah* means a fire district or volcanic region. One of these, not far from Medinah, erupted

during the reign of the Caliph Omar, and this is the last sign of activity of which we have historical notice.

As we travel northwards, small basaltic flows are noticed in Moab, and these prepare us for the great lava-covered districts which lie to the east and north east of Galilee, whilst many smaller ones are noted in Galilee itself. The upland plain of Damascus seems at one time to have been enveloped in a semicircle of fire, of which remains are to be seen in the three huge fire districts of the Safâh, the Ledja (including the Hauran), and the Jaulan. Jebel Kuleib (5,600 ft.) is the Hill of Bashan, and the country thence to the Jordan contains some barren scoriaceous districts, and other of extreme fertility, where, the basalt in decomposing, mixes with a peculiar loam. This probably nourished the vegetation on which the bulls of Bashan waxed fat. Enormous quantities of magnetic iron ore occur in the hill of Bashan, in fact, no part of the country calls for exploration more than this does.

Many of the basaltic blocks are covered with inscriptions and figures of beasts, &c. Basalt, in fact, seems to have been much in favour as a medium for inscriptions. Take the case of the Moabite stone for instance. Canon Tristram says that it was much in favour with the old Cyclopean builders. Most of the specimens from Moab and Galilee brought for analysis are olivine dolerites, extremely rich in iron, and rather poor in silica.

It might be asked, what is the age of these masses of Basalt? When did the eruptions begin, and when were they brought to a close? As a partial answer to the first question, M. Lartet observes that no basaltic fragments have been found in the older deposits of the Dead Sea basin, and, as these include pebbles towards their margin, it would seem as if the basalt had not reached the surface when the oldest Dead Sea deposits were made. On the other hand, there is no tradition which can plainly be identified with volcanic activity, in those regions where volcanic matter is now found. It is plain that the fate of the cities of the plain was in no way connected with volcanic eruptions, as this is just that portion of Palestine which is most free from anything of the sort. The age of the volcanic eruptions awaits further investigation.

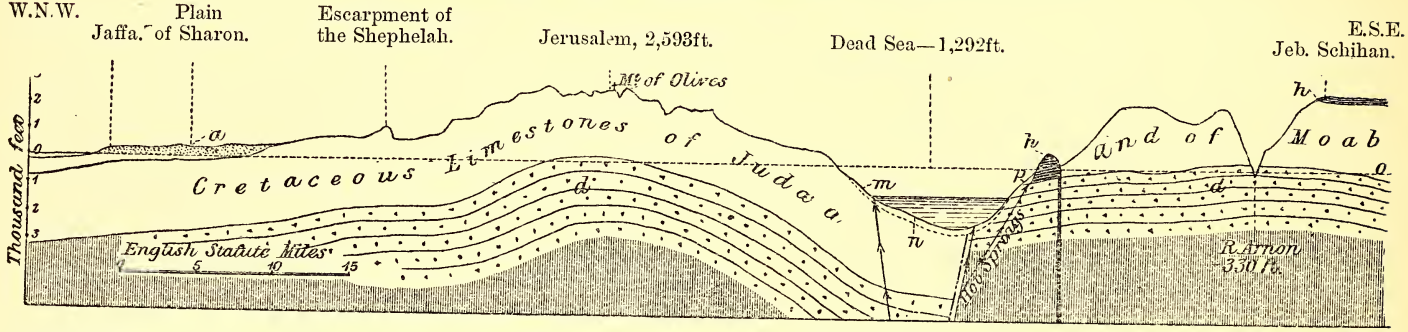
8. *The Jordan Valley and Dead Sea Basin.*—This is the most important of all the sections, and I have been obliged to hurry over some of the others in order to arrive at it. The others being more or less necessary to a correct understanding of this one. By Dead Sea Basin I mean the whole of the longitudinal fissure from the slopes of Hermon to the water-shed near Akabah. The drainage of this finds its way into the Dead Sea, on the north by the Jordan valley, on the south by the Wady Arabah. From the surface of the Dead Sea it is dissipated by evaporation, whereby the level is maintained, and maintained so effectually, that a depth of nearly thirteen hundred feet intervenes between its surface and the level of the Mediterranean, so that the very clouds in this valley are often hundreds of feet below the level of the sea.

Broadly speaking, there can be no doubt of the general connection between the Dead Sea fissure, the Gulf of Akabah, and the Red Sea, right away to the Straits of Babel-Mandeb, and the line of depression is carried north in the hollow of Syria, between Lebanon and Anti-Lebanon, though there above the level of the sea. Such a singular place has been fruitful in theories, and the destruction of the cities of the plain for instance, has led travellers to endeavour to account for the facts of biblical history, by statements too often entirely devoid of truth. The craters of De Saulcy, &c., have no existence. And it so happens that the volcanic eruptions are quite in another part of the country, as we have already seen.

There are two theories which claim our attention as not being obviously inconsistent at first sight with physical facts. One is, that previous to the disaster of the Pentapolis, the river Jordan flowed into the Gulf of Akabah; the other is, that the Red Sea came right up over the present water-shed, and filled the great fissure almost to the foot of Hermon. According to the first view, the whole system would be fresh water, according to the second it would be marine.

Before entering on this question generally, we should direct our attention to the geological structure of this fissure basin, in connection with the high grounds of Judæa and Moab. Figure 7 is a diagramatic section of Palestine from the coast to the mountains of Moab. The Cretaceous limestones rising from beneath the waters

FIG. 7.—GENERALIZED GEOLOGICAL SECTION ACROSS PALESTINE.



o, Level of the Mediterranean; *a*, beds of the maritime plains; *m*, old lacustrine deposits of the Dead Sea basin; *n*, deposits now forming beneath the Dead Sea; *p*, tufaceous deposits of hot springs; *h*, basalt.

of the Mediterranean, and the recent deposits in the Vale of Sharon, ascend by a major anticlinal fold to the plateau of the Judæan highlands, whose physical geography we have already studied. The Mount of Olives and the country to the eastward, is occupied by the very highest beds of the Cretaceous series, the soft white chalk-with-flints. On this side of Jerusalem there occurs a preponderance of easterly dips in these limestones, which the various local sections well bear out. The consequence is that the beds come down with an increasing dip, and thus in all probability pass right under the Dead Sea in the manner shown in the section, where they are sharply faulted against the Nubian sandstone, which is seen only on the east side. Here a general westerly dip is said to prevail, at any rate near the Red Sea, in the manner shown, so that if there is no fault, there must be a synclinal curve with arms of very unequal steepness, which would have all the effect of a fault. Whichever of these views we adopt, the chasm must in the main be due to stratigraphical causes, and not to erosion, as in the case of a canon.

I will also note one or two points which this diagram suggests: The deposits marked *a*, are those referred to so briefly in section 6, the raised beaches, blown sands, &c., of the plain of Philistia and the Vale of Sharon; the deposits marked *m*, are old deposits of the previous Dead Sea, to which allusion will presently be made; the deposits marked *n*, are those now forming beneath the Dead Sea itself; the deposits marked *p*, are those produced by hot springs, of which Zara and Calirrhöe are the most remarkable on the east side of the Dead Sea. There is also a hot sulphur spring on the west side near Masada, which no doubt deposits slightly. Tufaceous limestone, sometimes aragonitic, is the principal substance deposited by these hot springs. There are small eruptions of basalt also on the east side of the Dead Sea. The lines which indicate the upcast pipes of the hot springs, are of course somewhat hypothetical, but there can be no doubt whatever that the thermal conditions of the Jordan valley have some connection with this line of fissure, be it actual fault or unequal synclinal.

Having thus far studied what I may term the geological accessories of the Jordan valley, we must now enquire into the nature and

probable age of its deposits, including of course those of the Wady Arabah, and see how far their history bears on the question of the sudden sinking of the Dead Sea basin, which has been supposed by some to have been the cause of the ruin of the five cities.

Now M. Lartet maintains that the great fissure has been an independent basin for a long period, indeed, at one time he was disposed to regard its origin as having dated from Miocene times, but in his latest work *La Mer Morte*, he does not seem disposed to carry it so far back in time. But that it has been an independent basin for an immense period, he considers can be shown in many ways. Firstly, as was noticed by Hitchock, from the surveys of Robinson and Smith, all the tributaries of the Arabah flow in so as to form an acute angle with the main valley pointing to the north, a very strong physical proof that the drainage of that region has not been reversed. On the other side of the Dead Sea the lateral wadies of the Jordan system for the most part point to the south; all the evidence indicating that the drainage has been towards the Dead Sea in former times just as it is now.

But in spite of these facts, so ably put forward by Hitchcock and Lartet, it must be admitted that the zoological evidence does point to the probability of some connection, doubtless of very high antiquity, with an African continental river system. Canon Tristram, with his usual energy, brought to England numerous specimens of fish from the upper waters of the Jordan system, probably from the lake of Tiberias. Some of these were decidedly of African types. According to Dr. Gunther the following genera occur, viz.: *Chromis*, *Hemichromis*, and *Clarias*. Now *Clarias macracanthus* is a common fish of the upper Nile. But to show the remote nature of the connection, it is a curious circumstance that *Hemichromis* in not represented now-a-days in N.E. Africa, but chiefly in the central African lakes and even in the west coast rivers.

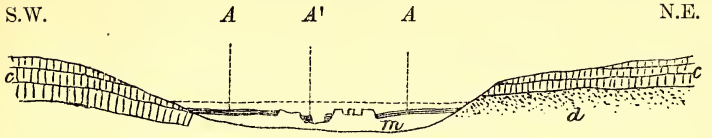
On the whole, Dr. Gunther, who had the examination of Tristram's fishes, demurs to M. Lartet's notion as to the complete independence of this valley system. Nevertheless, an examination of the nature and mode of occurence of the Jordan valley deposits, as shown both by M. Lartet and Captain Conder, prove the very

considerable antiquity of the valley as an independent basin, and thus show how impossible is the theory which would date its origin fron the catastrophe of the Pentapolis.

Captain Conder shows four very distinct margins of old lakes, which were predecessors of the present Dead Sea. The present north shore of the Dead Sea is a shingly beach with a ridge of pebbles at the top of a somewhat steep slope. About thirty feet above the top of this is a similar one. This marks the surface of extinct lake No. 1; a hundred feet higher is a third beach, which marks the surface of extinct lake No. 2. Above these beaches, and some 300ft. above the present Dead Sea, are flat shelves of marl, known as the Siddim level; this marks extinct lake No. 3. And there is yet another still higher. All these lakes would obviously fill up a considerable expanse of the valleys of the Jordan and the Arabah, and their deposits would serve to give us some idea of the history of the period. These lacustrine deposits M. Lartet calls the "deposits of the Lisan," from their great development in that peninsula, which wholly consists of them. They are, as a rule, very thin bedded marls with much salt and gypsum, both in beds and throughout the mass, and have considerable resemblance to deposits now going on at the bottom of the Dead Sea, where crystals of salt and selenite are brought up from the bottom, along with blueish marl. From the absence of organic remains, M. Lartet argues that the physical conditions must have been pretty much the same as now, except probably for the greater quantity of water, and this, M. Lartet considers, is due to the much greater humidity of the atmosphere during Quaternary times.

Anyhow, what we have before us in these Jordan valley deposits, is pretty fair evidence, both on the testimony of Conder and Lartet, that neither the waters of the Red Sea, nor of a fresh water system, have prevailed over that area where these saline and gypsiferous marls have been thrown down, and consequently the existence of these old saline lakes at much higher levels than now is proof of the considerable antiquity of the present depression. Indeed, as Captain Conder remarks, no less than four Dead Seas had dried up before the days of Abraham.

FIG. 8.—SECTION ACROSS THE JORDAN VALLEY.



A, Alluvium and other superficial deposits; *A'*, silt of the river Jordan; *m*, old lacustrine deposits.

Figure 8 serves to show the relation of the old lacustrine deposits, which are remarkable for their sterility, to more recent fluviatile and torrential deposits, usually of a much coarser nature, brought down and again cut into by the Jordan and its tributary wadies. This secondary valley in which the Jordan runs is known as the Zor, whilst the larger or primary valley is known as the Ghor. These fluviatile deposits are often just as fertile as the old saline lacustrine deposits are sterile.

There are many other subjects of interest connected with the Jordan valley, such as the evidence of climatal changes, &c., but we have no time for these. Before concluding I must just allude to the hot saline springs in the Jordan valley. Of these I will only mention three, although Dr. Salah Merrill has pointed out several others. It is clear from the abundance of these springs all along this great line of fault, that the forces of vulcanicity are not yet wholly quiescent, although lava no longer flows from the neighbouring craters of Galilee and Bashan. Indeed, so late as 1837, the inhabitants had a reminder of the fact, in the earthquake which destroyed the city of Tiberias and killed thousands of people.

That there is no necessary connection between Sulphur waters and volcanicity the evidence of Harrogate will show, but when waters are thermal over a long line of country, we naturally regard hot water as proof of heat somewhere.

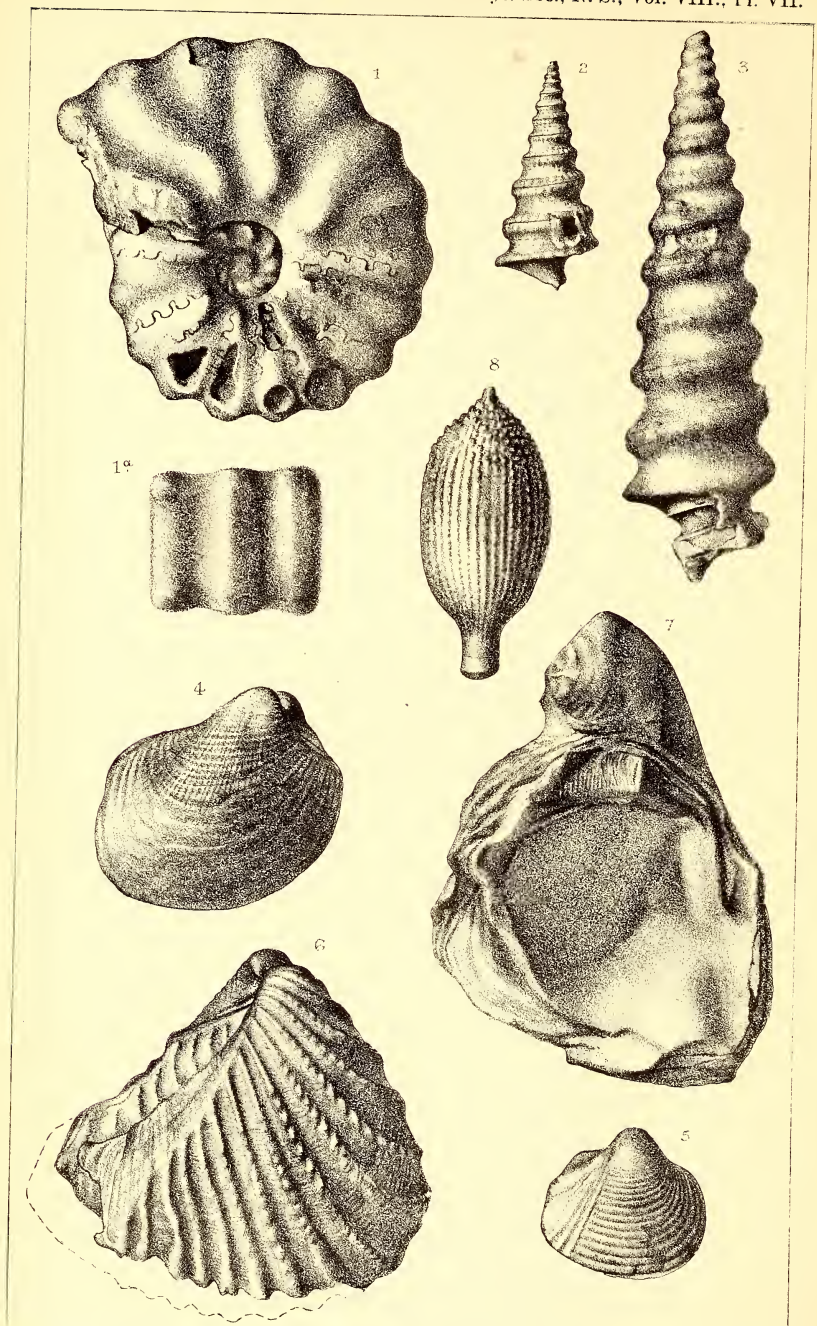
There is a remarkable hot spring at Gadara, near the junction of the Jabbok with the Jordan. I mention this particularly, because, according to Dr. Merrill, this place has natural advantages, which will cause it to become the Montpelier of Syria some day. I think he mentions five sulphur sources. There are magnificent views from this place, which was evidently a favourite one in the days of the

Roman empire, from the numerous remains of villas in the environs. It only requires that the detestable Bedoueen should be driven away, for the place to become one of the most charming in the east. Allusion has already been made to the hot springs of Calirrhöe, and to the marvellous scenery of the gorge in which they occur. These are hotter than the Gadara waters, being about 140° F. This also is about the temperature of the hot springs of Emmaus, on the west side of the Lake of Tiberias, which have been made the subject of analysis. There is considerable general analogy between these waters, and those of Harrogate. The water of Emmaus is a highly saline sulphur water, containing bromide of magnesium in very appreciable traces.

We cannot quit this part of the subject without a word about the waters of the Dead Sea.

Well may the Arabs express astonishment when they see the spring floods of the Jordan swallowed up year after year, without any material increase in the size of the lake. To them the notion of evaporation will hardly present itself,—an evaporation which makes this place the recipient of everything that is soluble throughout the valley.

The waters are so bitter and briny, that the fish of the Jordan are pickled at once, and cast up on its shores. Some persons have started the idea that the waters of the Dead Sea owe their salinity to the vicinity of Jebel Usdom, but when we compare the composition of the salts of the Dead Sea waters with those of the Salt Mountain, it is at once perceived that such can not be the case. The rock salt of Jebel Usdom is nearly pure Chloride of Sodium, so that nothing but common salt and gypsum could be obtained from this source. Let us now turn to the composition of the waters of the Dead Sea. The amount of saline matters vary much according to position and depth. Samples from considerable depths contain $\frac{1}{4}$ of their total weight as dissolved solid matter; the salts of magnesium exceed those of any other base, and there is a very considerable proportion of bromide. Sodium, calcium and potassium come next in the order named; all these exist principally as chlorides and sulphates; carbonates are very scarce. There can be no doubt



G. M. Woodward. lith.

West Newman & Co imp.

Cretaceous fossils, from the Lebanon & Palestine.

that the numerous hot springs in the Jordan valley have supplied a large quantity of the saline matter; and we know that the one at Emmaus contains bromine. During the long ages when the four extinct lakes were in existence, their waters were relieved by constant deposits of common salt and gypsum, but so very soluble are the haloid salts of magnesium, that these have not even yet been deposited in any appreciable amount, and, although the present lake yet continues to deposit cubes of salt and lenticular crystals of selenite in the marly mud which is forming at the bottom, it would seem that magnesian salts still remain for the most part undeposited. Thus the present Dead Sea contains the magnesian chlorides and bromides, not only of its modern affluents, but those also of its four progenitors.

The deductions which the chemical geologist is enabled to draw from these facts, are not the least valuable among the many marvels of the great Syrian fissure.

EXPLANATION OF PLATE VII

Fig. 1.—*Ammonites syriacus*, Von Buch. Lebanon.
Fig. 1*a*.—Portion of back of same specimen.
Fig. 2.—*Nerinæa* cf. *gemmifera*, Coq. Abeih, in the Lebanon.
Fig. 3.—*Nerinæa* cf. *Coquandiana*, d'Orb. Abeih, in the Lebanon.
Fig. 4.—*Pholadomya Vignesi*, Lartet. Judæa.
Fig. 5.—*Procardium*, species. Abeih, in the Lebanon.
Fig. 6.—*Trigonia scabra*, Lamarck. Abeih, in the Lebanon.
Fig. 7.—*Exogyra olisiponensis*, Sharpe. Judæa.
Fig. 8.—*Cidaris glandarius*, Lang. Lebanon or Hermon.

A GLACIAL DEPOSIT NEAR DONCASTER. BY THOMAS HILL EASTERFIELD (PL. VII.)

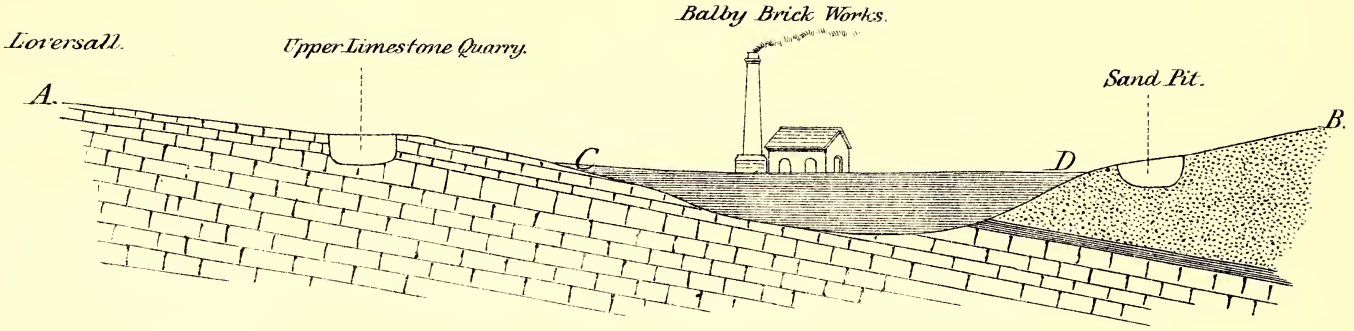
SPEAKING some months ago with Mr. Furnival, of Doncaster, our conversation turned upon glacial deposits, and Mr. Furnival stated that the clay in a clay-pit two miles south-west of Doncaster, and known as Balby Brick Works, appeared to be of the nature of a "Boulder-Clay." I took an early opportunity to visit the pit, and found it to be undoubtedly what is known as "till." It consists of a tough dark-blue clay, packed with boulders up to half-a-ton in weight. The boulders are mainly of local origin, magnesian-limestone, clay-ironstone, and coal-measure shales and sandstones being most abundant; though not unfrequently, carboniferous limestone and upper permian marl with gypsum are found, as are also a few small boulders of hæmatite. One very small block appears to be of the nature of a quartz-felsite. Very many of the boulders are beautifully scratched and polished by the action of the ice.

From a boring made some years ago it appears that this clay is sixty feet in thickness. It covers the outcrop of the New Red Sandstone at its junction with the Magnesian Limestone, there being a limestone quarry near one end of the clay, and a sand-pit close to the other, as in the section on the opposite page.

The section is ideal, only being intended to convey a rough notion as to the general lie and position of the beds.

The clay consists of two parts, an upper and a lower, and the surface of the lower appears to have been smoothed by the ice before the upper was deposited. This division in the clay seems to indicate a cessation in the glacial action, but there is no distinctive difference between the boulders of the upper and those of the lower clay, though there is rather more magnesian limestone in the lower than in the upper.

Section at Balby Brick Works, near Doncaster.



From C. to D. is about 300 yards; in the direction at right angles to this the distance has not been determined, it is however at least a quarter of a mile.

A. Megson & Sons, Leeds.

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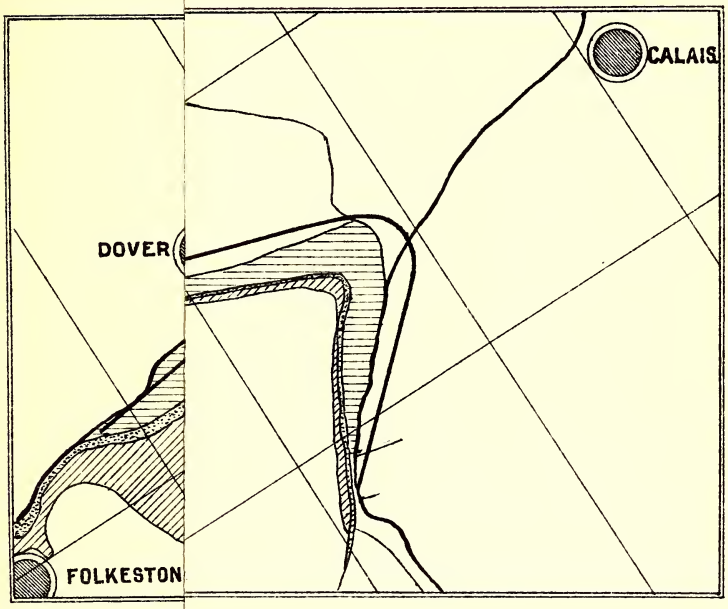
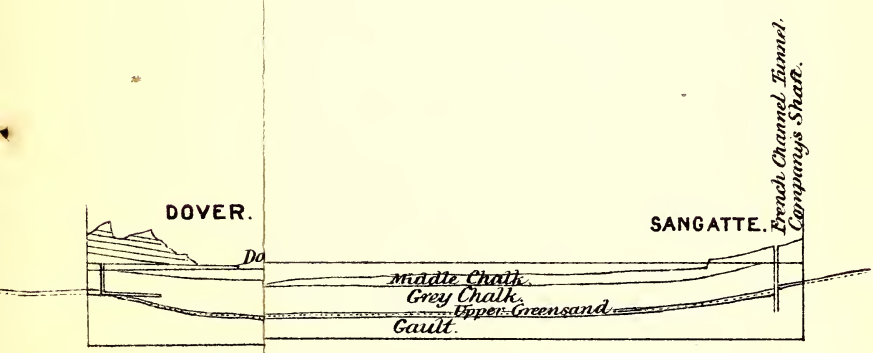
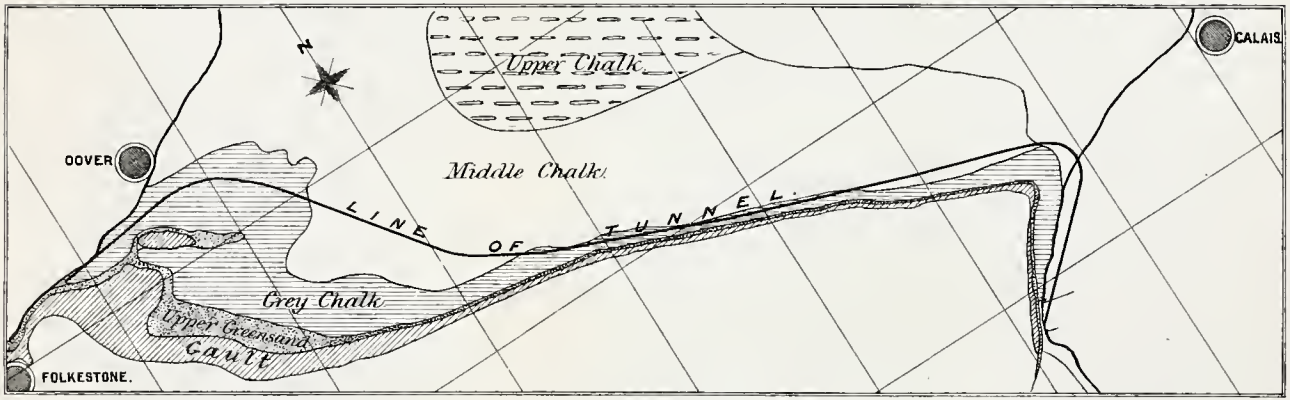




A. Megson & Sons Lithos. Leeds.

Geological Plan of the Channel between Dover and Calais.

(Taken from Mr. C. Tylden Wright's Paper)



Scale of English Miles.

0 1 2 3 4 5 Miles.

Section of Strata under the Channel.

(Taken from Mr. C. Tylden Wright's Paper)

A. Megson & Sons, Lithos, Leeds

Horizontal Scale 3/8 in. to 1 mile
Vertical . 1600 feet to 1 inch

NOTES ON A VISIT TO THE CHANNEL TUNNEL. BY ARNOLD LUPTON, M. INST. C. E., F.G.S., ETC. (PLS. VIII. AND IX.)

THE writer is indebted to the paper of Mr. C. Tylden Wright, read at the North of England Institution of Mining Engineers; and to other sources for much of the information contained in this paper. From these, as well as from his own notes, he has obtained various details, and has prepared the diagrams to illustrate his remarks.

Last November (1882), the writer was invited to accompany a party of Mining Engineers, to visit the works of the Channel Tunnel near Dover. A shaft 163ft. deep is sunk between the Railway and the sea-shore, and from the bottom of this, a small tunnel 7ft. in diameter is driven a distance of 2,000 yards under the sea, in the grey chalk, may be described either as a *soft stone* or as a *hard clay*. The plan and section will explain their relative position.

It is proposed to drive the tunnel with an inclination down-hill of 1 in 80 from the shore at each end, for a distance of 2 miles, and then to drive it with a rising gradient of 1 in 2,000, to the centre of the channel, so that the water met with under the sea, may run to within two miles of the shore, from which point it may be pumped in pipes, or conveyed by a level heading to the shafts, and there pumped to the surface.

The heading is driven by the machine of Messrs. Beaumont & English, which cuts away the whole face of the headings, and delivers the fragments at the back of the machine; it will advance $\frac{5}{8}$ inch a minute (as witnessed by the writer), this is equal to $37\frac{1}{2}$in. an hour, viz.: 1 yard an hour or 24 yards a day, which equals $4\frac{1}{4}$ miles a year without working on Sundays. This, with an equal rate of progression on the French side, amounts to $8\frac{1}{2}$ miles a year, and the distance of 22 miles (21 yet to drive) will be accomplished in $2\frac{1}{2}$ years. It is quite reasonable to suppose that this may be done, because the machine has been driven at a greater speed than given above, upwards of 40 yards having been driven in one day. It is intended to drive the tunnel at such a gradient that there shall not be less than 150ft. of strata between it and the deepest part of the sea. The stratum of grey chalk is 226ft. thick, and extends all the way from the French to the English coast; it is a water-tight stratum; at the English

end only a few drops of water are to be seen in the tunnel, at the French end there is a good deal of water owing to some faults.

It is not likely that much water will be met with in driving the tunnel, as owing to the soft clayey nature of the grey chalk, it is hardly possible for it to contain any fissures, because the weight of ground and water above, would tend to consolidate the ground. But if water should be met with, even in large volumes, it can be tubbed out with cast iron cylinders, by a process well-known to the sinkers of coal shafts. Each feeder of water can be tubbed out as it is reached, so that the total volume of water to be dealt with at once, need never exceed a quantity that can be easily pumped up.

After the 7ft. heading has been driven, it will be enlarged to a tunnel 14ft. wide inside the lining; the lining is to be made of cement concrete, the grey chalk excavated from the tunnel being used for this purpose. It is proposed to make two separate tunnels, one for each line of railway. This will be easier to make than one large tunnel, because the chalk is not strong enough to stand in a wide excavation; and also, because if an accident should happen to one line, the other will not be blocked. And it will diminish the first cost of the tunnel, because one line can be completed and worked before the second line is made, and traffic developed.

The cost of the tunnel need not apparently be very great, because there is no money to be paid for the land, and it would be impossible to find any ground more suitable for a tunnel than the grey chalk.

The tunnel cannot be worked by steam engines, the products of combustion would be too dangerous and offensive; but it may be worked either by compressed air or electrical engines. There is no reason why compressed air locomotives should not be used; they are used now to a considerable extent in coal mines and elsewhere. The loss of power in using compressed air is very large, from 60 to 80 per cent., but this is compensated for to a great extent by the greater economy of the stationary air compressor as compared with a locomotive; the boiler of the latter is expensive to repair, and it requires the best fuel; a stationary air compressing engine need not use more than 2lbs. of cheap fuel per horse power per hour, and this will not mean more than 10lbs. of fuel per indicated horse power of

the locomotive. Taking all the circumstances into consideration it will be difficult to find any much more economical power than compressed air; and it has this advantage, that the air given off by the locomotive will be sufficient for the ventilation of the tunnel.

The locomotive proposed it is thought will take a train weighing 150 tons, gross, at the rate of 30 miles an hour. Whilst the exhaust air from the engines will very likely suffice for absolute needs, yet it will probably be advisable to have a regular current of air, about 50,000 cubic feet may be sufficient, and this can be obtained by means of a fan and engine, such as are used for ventilating coal mines.

At present Colonel Beaumont has a locomotive made ready for hauling the dirt out of the tunnel, which is now working on the surface. It is a small locomotive using air at a pressure of 1,000lbs. which is heated by a very small coke fire, this facilitates expansion and prevents freezing in the ports, the air is expanded down to atmospheric pressure by compound engines of which the high pressure cylinders are 2 in. in diameter and the larger cylinders 7 in. in diameter.

The tunnel, whilst it is being driven will be ventilated by the exhaust air from the excavating machinery. It is now lighted by the "Swan Electric Lamp," of which there is a series fixed along the side so that the whole length is illuminated.

There is also no doubt that the traffic in the tunnel might be worked by electricity as a motive power. And before the tunnel is completed it is probable that great progress will have been made in the construction of large engines worked through the agencies of magnetism.

It is quite possible to construct both the tunnels under the sea at the rate of £50 a yard each, or a £100 a yard for the two, which amounts to £176,000 a mile, and 25 miles at this rate will amount to £4,400,000 or with approaches, apparatus for air compressing, rolling stock, &c., &c., say £5,000,000 in all. The interest in this at 4 per cent. will be £200,000 a year. It is difficult to see how the tunnel can fail to be profitable. Suppose for a moment England and France to be connected by a narrow isthmus, can it be supposed that a railway to connect the two countries would not pay, and if so

the tunnel should pay well. The cost of the London and North Western Railway is about £60,000 a mile, which at present prices of stocks is worth about £105,000 a mile. Taking the cost of the tunnel and approaches at £5,000,000 and the length of the tunnel and approaches included at 31 miles (the approaches costing per mile much less than the tunnel), it equals about £161,000 a mile; when the great length of comparatively unprofitable line possessed by the London and North Western Railway Co. is considered, and the fact that all the railway systems of two great countries will converge at the tunnel, there can be no doubt that the expenditure will be profitable from a commercial point of view.

With well-built and well-lighted carriages, the journey will be at least as pleasant and safe as travelling at night is on an ordinary railway, and there can be no doubt at all that the passenger traffic between England and the Continent will be enormously increased; the dread of sea sickness is a real and widely operative cause for people stopping at home, both with Englishmen and foreigners.

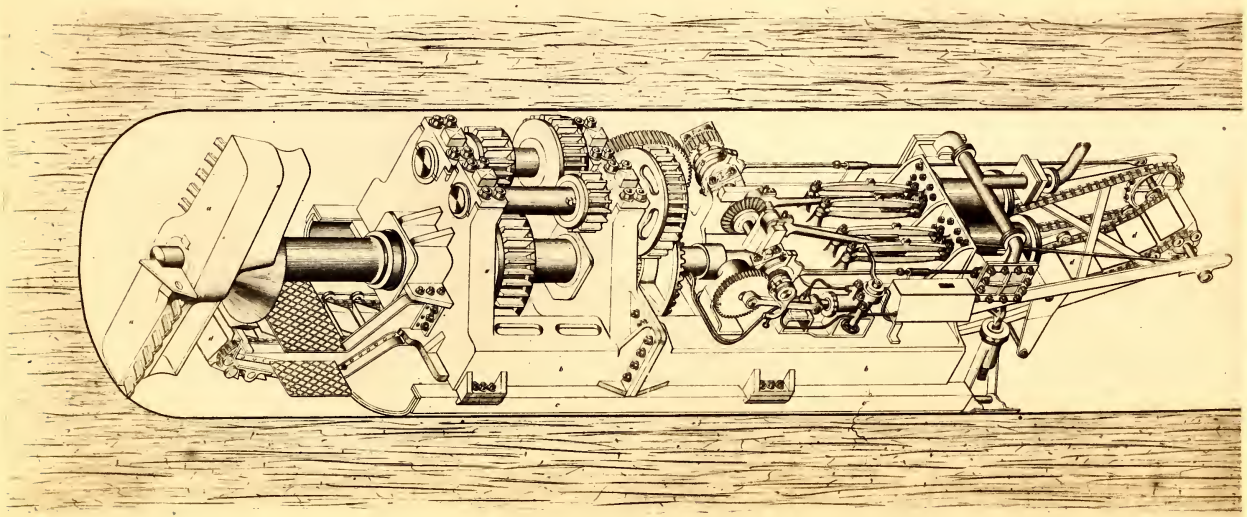
The only real objection to the tunnel is the danger in case of war; the danger is not of soldiers coming through in the first instance, but of a landing from ships of a large army which would seize the tunnel head and then be able to obtain supplies and reinforcements which our fleet would be powerless to stop. It is, however, possible to diminish if not to destroy this danger, by constructing near the entrance to the tunnel a fort of iron or steel, which should be absolutely impregnable and armed with powerful cannon. A garrison of 1,000 men would be sufficient to man a steel fort 100 feet high and 100 feet in diameter, which would have deep cellars in the rocks containing ample stores of all kinds and accomodation for the men.

An army of 50,000 men would vainly strive to take a fort of steel whose entrances would only open to pour forth a withering fire from monster ordnance directed to the tunnel, or opposing batteries, or from rifles, or machine guns, directed by carefully chosen men who would be absolutely protected from the enemy's fire; the fort would also be assisted by the fleet; because unless our fleet had the command of the channel, the enemy would not

To illustrate Mr. Arnold Lupton's paper on "The Channel Tunnel".

SECTION OF THE PRESENT HEADING UNDER THE SEA AT DOVER,

SHOWING THE AIR BORING MACHINE OF COLONELS BEAUMONT AND ENGLISH IN ISOMETRICAL PERSPECTIVE.



Scale of Feet.

IN. 12 9 6 3 0 1 2 3 4 5 6 7 8 9 10. FEET.

PLATINOTYPE PERMANENT PHOTOGRAPH.

S. A. Wörtenbrom Leeds.

require the tunnel by which to bring up his reinforcements, as they would come by sea.

The cost of such a fort, exclusive of its armament, need not be more than £620,000, or say one million including armament, or in other words, an impregnable land fort could be made and armed for the cost of a first-class ship of war. With the knowledge that such a powerful fort existed, no foreign General would venture to land an army in England, whose only chance of safety depended on the tunnel as a base of operations, and thus whatever danger might arise from the tunnel would be continental, and that without cost beyond this outlay, because the garrison of 1,000 men could be easily provided, out of the standing army already existing.

Many contrivances for flooding the tunnel, or otherwise stopping it, even after an enemy had got possession of it could be provided as additional precautions, and the tunnel once stopped, the enemy having no base of operations, or chance of reinforcements, would have to surrender at discretion, unless our fleet was also destroyed, in which case the tunnel even if open and in the enemys' hands would not add appreciably to our danger.

The writer therefore considers that it is demonstrated that the construction of the tunnel is practicable, that it will be profitable, and no cause of danger to any one.

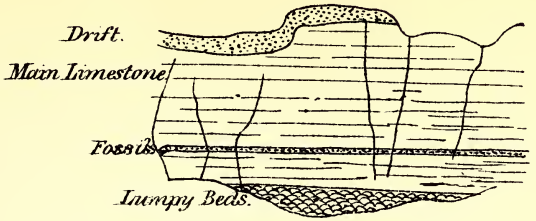
ON THE SEQUENCE OF THE PERMIAN ROCKS NEAR RIPON. BY REV. J. STANLEY TUTE, B.A. (PL. X.)

THERE is considerable difficulty in determining with certainty the bottom beds of the Permian Rocks, near Ripon. Some beds, indeed, are seen to rest unconformably upon the Plumpton Rocks, as in Studley grounds beneath the 'Surprise,' near the Abbey, and at Knaresbro'. But these seem to me not to be actually the lowest beds of all, though, of course, they are the lowest in those places. Other beds occur as at Nordhouse, in Aldfield, and Well; which cannot be assigned to any position among the rocks which appear in these three places, or in the rocks above them, and must, therefore, have an horizon below. The Carboniferous Rocks had suffered immense denudation before the Permian period. If the Coal Measures ever existed in this neighbourhood (which I doubt), they had all been washed away, and much of the underlying millstone grit. If they did not exist, then the grit must have been exposed during the whole period of the Coal Measures to aerial denudation, and the consequence must have been the formation of considerable river-valleys, into which, as the land was sinking during the Permian period the sea flowed, and the earliest deposits would naturally be made in these ancient valleys. In lithological character also, as well as in the manner in which the fossils are preserved, the beds at Aldfield and Well, differ from the rest of the Permian series. At Well, the fossils seem chiefly to consist of Producta horrida; at Aldfield I have found more than twenty different kinds, most of which occured in a very thin band of clay, which has now been exhausted by the extension of the limestone workings.

The bed which seems to lie above this conssits of small slabs of yellowish limestone containing Axinus obscurus, very similar to the Garforth limestone, near Leeds.* It occurs in the Studley ground beneath the "Surprise"; and at Hob Green, in Markington. It is difficult to determine the actual thickness of these two beds, but they certainly cannot together be less than 50 or 60 feet.

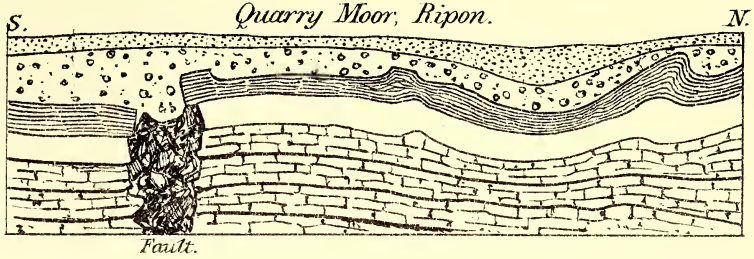
Above them is another bed, well exposed in Markington, of at

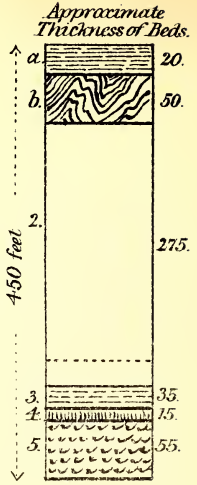
* At Garforth, the Limestone lies upon a bed of sand, which seems to have been derived from the Carboniferous rocks, and is probably a passage bed of Permian age.

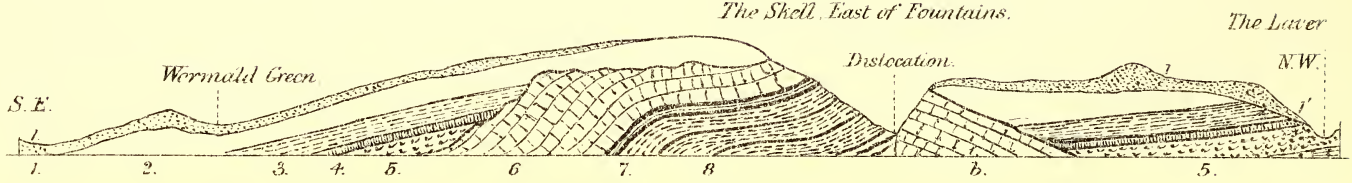


Old Quarry near Wormald Green.

Dip 6° N.E.







1. Upper Boulder Clay. 1'. Lower Boulder Clay. 2. Main Limestone. 3. Lumpy Beds.
4. Garforth Beds 5. Northouse Limestone. 6. Plumpton Grit. 7. Cayton Gill Beds.
8. Lower Grits a. Upper Limestone. b. Contorted Beds of Gypsum.

least 50 feet in thickness, of a peculiar character. The surface of each layer is irregularly covered with small lumps or bosses, as if the Permian sea had been subjected to a set of various cross currents, which disturbed the natural process of horizontal stratification. It is a somewhat dark, yellowish, unfossiliferous limestone, full of the sparry cavities so characteristic of the Magnesian limestone. To this bed succeed others of solid limestone, which form the main deposits of the district, and are probably about 275 feet in thickness: they are quarried at Wormald Green, Markenfield, Quarry Moor, and in many other places. In some of its lower beds this limestone is a good building stone, of an agreeable creamy-white colour; but more suitable for interior than exterior work. Fossils are occasionally found, as in two layers in an old quarry near Wormald Green. Old weathered stones also occasionally exhibit the presence of fossils, though they can seldom be separated from the matrix. In the upper beds in a quarry a short distance west of Markenfield Hall, there are many casts of fossils. Here the limestone is of a darker colour, and not so pure.

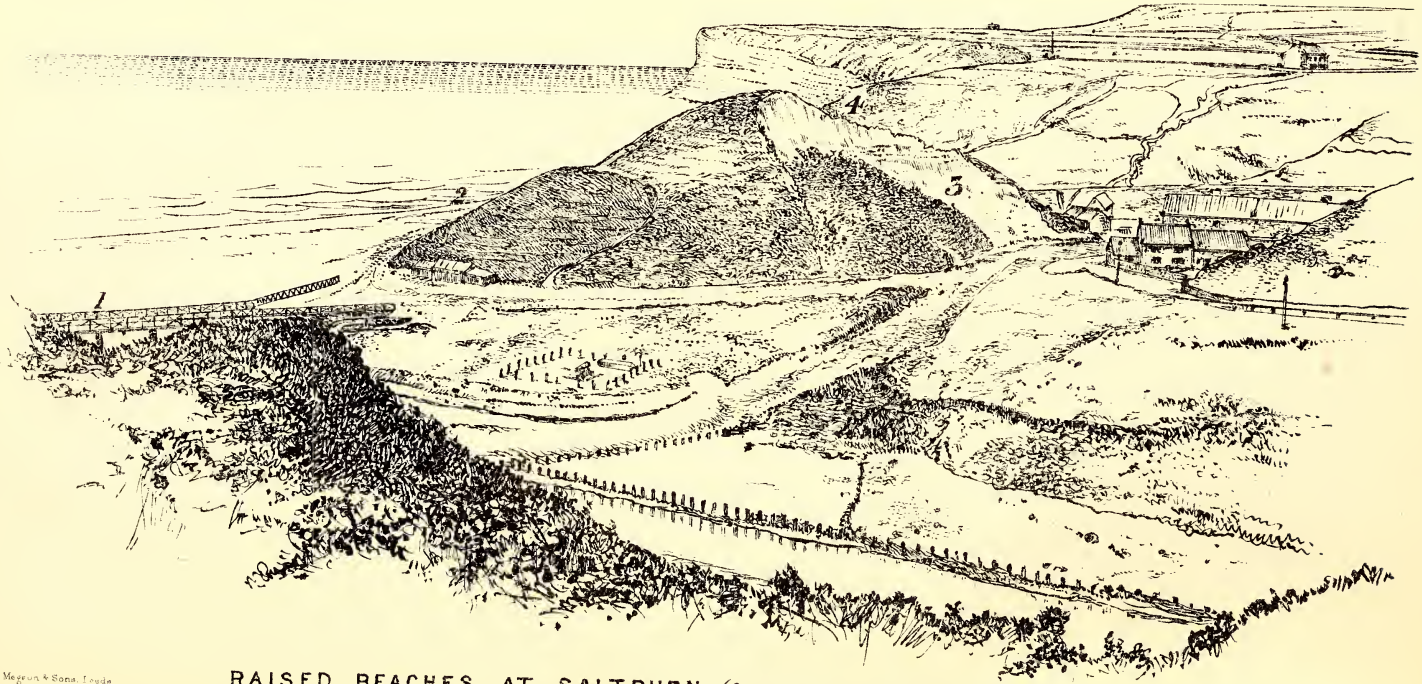
In the quarry belonging to Markenfield Hall, the limestone presents in its structure a close resemblance to the limestone at Ryhope, in the county of Durham, and in an old wall near the Hall I have found a portion of limestone of the same hard semi-crystallized form as that of Tunstall Hill, but have never discovered the bed from which it was taken. We may, therefore, assign the Markenfield beds to the same horizon as the Ryhope Limestone. Belonging to the main limestone there is a bed which is perfectly oolitic in an old quarry in Whitcliffe Lane. At Nidd Rock an oolitic limestone has disintegrated into a kind of gravel of small rounded grains, but larger than those in Whitcliffe Lane.

The whole of these rocks seem to have been deposited in a shallow sea; for at Wormald Green the clay-partings are strongly ripple-marked, and many layers, when weather-worn, exhibit marks of false-bedding. Above the main limestone I am inclined to place the beds of Gypsum, which occur north of Ripon. They consist of layers of Gypsum and a red sandy clay which have been violently contorted, and they are about 40 feet in thickness. They are over-

laid by the horizontal beds of the Upper Magnesian Limestone. As far as I have been able to discover, the whole series has only been slightly dislocated. At Nordhouse, there are two parallel faults running N. and S., throwing down the strata about a yard. At Monkton Mains Quarry there is another small east and west fault, and a third at Quarry Moor. The strata are occasionally bent, as at Quarry Moor and Wormald Green. There is a fault, however, running east and west from Fountains Abbey, and passing a little to the south of the "Surprise," which seems to have thrown down the Magnesian Limestone considerably to the north. At Wormald Green, when the drift is removed, the surface of the limestone exhibits evident marks of denudation,—it is sometimes worn into "pot-holes," sometimes into rounded and smoothed bosses. But I have not seen anywhere traces of glacial striations, except in a few Magnesian limestone boulders picked out of the drift.

SOME INDICATIONS OF A RAISED BEACH AT REDCAR. BY REV. J. S. TUTE, B.A.

AT Warrenby, a new village near Coatham, there is a bed of sandy clay, containing many shells of Rissoa ulva, with broken mussel and cockle shells, &c., and the vertebræ of fishes. Sections were obtained when the foundations were made for the houses, showing a horizontal structure. Here the surface of the land is about 14 feet above high water mark. It would appear that these shell beds were the estuary deposits of the Tees, and that the coast has been raised probably 20 or 25 feet since they were deposited. On the east side of Redcar the Boulder-clay is about 6 feet above the high water mark, and only rises at a very small angle to the east. The upper portion is black, sandy, and peaty, passing insensibly into the browner clay below. This again seems to indicate the former existence of a lower level. These indications of a raised beach are, however, not absolutely conclusive evidence, but I think it is worth while to draw the attention of Geologists to them.



A. Megeun & Sons, London

RAISED BEACHES AT SALTBURN. *(SEE Mr W. Y. VEITCH'S PAPER.)*

ON THE RAISED BEACHES ON THE NORTH EAST COAST OF YORKSHIRE. BY W. Y. VEITCH, ESQ., M.D. (PL. XI.)

AT the estuary of the Tees, and on the adjoining coast, there are several indications that alterations in the sea level have taken place, embracing a period ranging from pre-glacial to recent times. They are, perhaps, of sufficient interest to be recorded, and this ought to be done as nearly as possible in the order in which they probably occurred.

Ancient river beds.—The most convenient physiographical records as a starting point, are the ancient river beds. The numerous borings taken in this district, prove that the pre-glacial stream which carried off the water to the sea from this neighbourhood, did so at a level considerably below the present low water mark. Its bed is traceable from the river Tees, near Newport, where it enters the county of Durham, and takes the direction of Saltholme, where it is ascertained by a boring to be 98ft. deep, and filled with sand and gravel; the following is the section:—

	FEET.
Sand	35
Warp (a fine carbonaceous mud)	15
Sand	23
Warp	23
Gravel	2
Into the red sandstone	1
	99

It is next traced to Port Clarence, where boulder clay at a depth of 77ft. was proved, according to the following section:—

	FEET.	INCHES.
Soil	1	6
Clay	4	—
Dark Sand	7	6
Clear Sand	26	—
Red Clay	3	—
Sand and Gravel	8	—
Boulder Clay	27	—
Into the red marl.		

By the following boring it is indicated at the works of Messrs. Bolckow, Vaughan & Co., at Middlesbrough:—

	FEET.
Made ground (Slag, Chalk &c.)	11
Dry Slime or River mud	8
Sand with water	10
Hard Clay (dry)	10
Red Sand with a little water	1
Loamy Sand do	3
Hard Clay	15
Rock, mixed with clay and water	11
Rock, mixed with clay, dry	1
Into Gypsum.	
	70

On the south side of the Tees, at the Tees Tilery, near Eston ironworks, boulder clay was proved over 100ft. deep. The valley persued its course past Kirkleatham to near Marske, where it joins the German Ocean, from under the boulder clay cliffs which guard this part of the coast. Borings near North Skelton, four miles south of Marske, show that the stratification has been washed out to a depth much below the bed of the present stream, and has been replaced by boulder clay, the inference being that this indicated the bed of a stream probably tributary to the one just described, which must have carried its water much further east than the present coast, to join the sea.

Glacial era.—Making these river beds the starting point, next came the glacial disturbance, about which my remarks will be limited to the evidence it furnishes me bearing upon my subject. It almost overwhelmed this district, grinding up the country, leaving striations recording the direction it travelled upon the local rocks, making Eston Nab, Hob Hill, and Roseberry Topping outlyers, bringing *débris* and boulders from the western part of the island, and filling up the submerged river beds. There being no boulders or drift above 800ft. in Cleveland, this, therefore, marks the highest point to which the water attained, although the ice must have passed over the Penine range at an altitude of 1,450ft., to bring over the fragments of Eden valley and lake district rocks, which are scattered so plentifully about.

Perforated stones at Wilton.—Having been informed upon very good authority, that there were to be found on the Wilton Castle escarpment, near Redcar, blocks of perforated rocks having the shells

of Pholadomya still retained in their cavities; the blocks being stones from a higher horizon than the rocks on the adjacent coast, all of the same kind of stone as the stratification near to which they were found, led me to believe that they might possibly record a beach somewhere about 150ft. above the present sea level, probably marking a pause in the upheaval which followed the submergence just referred to. I visited this part of the district in search for the Pholas bored blocks, but failed to find them. Subsequently I again searched, being this time accompanied by my friend, Mr. Barrow, of H.M. Geological Survey; disappointment again resulted. Mr. Barrow is, nevertheless, certain of their existence, and undertakes to point them out after referring to his map. It will, therefore, be unnecessary to say anything further upon this part of the subject at present.

Submerged Forest.—The next to be considered is what are generally termed the peat beds of Hartlepool and Redcar. Situate on both sides of the mouth of the river Tees, there are large tracts of peat and wood, suggesting either that they are the remains of an ancient forest, or accumulations of vegetable matter brought down from higher ground. On the north bed of the river the peat at the sea shore overlies the new red sandstone between the Stranton beach and the Longscar rocks. On the south side a similar bed is found over the lower lias between Redcar and the Saltscar rocks. After rough seas they are sometimes bared, and may be noticed to rest immediately upon fine blue clay, here and there stumps are to be seen with roots spreading through the peaty matter into the blue clay below, evidently in the position in which they originally grew. This same fact was observed by Mr. Charles Harrison, while engaged in superintending the construction of the Hartlepool Docks, where the same forest remains were come upon. Logs of wood, branches, twigs, and nuts are embedded in the mass, there being recognisable, oak, beech, and hazel, together with its leaves and nuts

The Tees Conservancy Commissioners in their dredging operations near Middlesbrough and Eston have brought up huge trunks of oak and vast quantities of vegetable matter, in fact, forest remains similar to the components of the sunk forest at Hartlepool and Redcar. Several antlers of the red deer have also been taken from

amongst the vegetable remains. One of these trunks of oak is preserved in the Albert Park, Middlesbrough, and when placed there it weighed eleven tons.

Thinking it possible that the deposit might extend inland, that is, to the west at Stranton, I obtained the following section from borings made in search of a water supply:—

Boring at the West Hartlepool Ironworks:—Passed through 50ft. of gravel and clay before penetrating the new red sandstone.

Boring at the Seaton Carew Ironworks, half-a-mile to the south of the last boring:—Passed through 60ft. of gravel only, before reaching the new red sandstone.

Attention will now be drawn to four sections which will throw some light upon the probable time at which this mass of vegetable matter was formed. In clearing away matter to form the central dock, at West Hartlepool, the following notes were taken:—

	FEET.
Gravel	3
Peat with numerous trees *in situ*...	6 to 8
(This bed thickens towards the timber ponds where it becomes 40ft. thick)	
Blue Clay varying from	2 to 6
Boulder Clay bored into*	20

We must now go to the Saltholme boring of Messrs. Bell Bros., where we have

	FEET.
Peat, earth and clay	8
Blue Clay	32
Brown and Red Boulder Clay	56

Passing on to the south of the river Tees to the Middlesbrough Graving Dock, there is

	FEET.
Peat	7
Silt	3
Into Boulder Clay	5

A section near Lackenby, beginning 9ft. below high water mark, gives

	FEET.
Sand and Silt	22
Blue Clay	3
Into Red Clay, no doubt Boulder Clay.	

* It is most probable that the thickening of the bed at this point is due to the gradual dissolving and washing out of the permian limestone below it during the growth of the forest, as it is here that the magnesian limestone crops out from under the new red sandstone.

These sections prove conclusively the post-glacial position of the forest remains. The presence of large numbers of the trees in the position in which they grew, and the absence of shells and other estuarine *débris* in the peat satisfies me that the deposits are not estuarine accumulations drifted from a higher level, but are the remains of a forest still located in its original locality. If these observations are accurate, they indicate a further upheaval followed by a submergence.

Raised beach at Saltburn.—A record of this kind of movement exists at Saltburn, where clear evidence of a raised beach, resting upon mid-glacial drift is noticeable; it is 35 feet above high-water mark, and consists of a band of alluvial sand containing shells and fragments of shells, such as Purpura, Litorina litoreæ, Trochus cinerarius, Natica globosa, Lachesis minima, and Cypræa Europæa; the two last being less common than the others.

The Saltburn Improvement Company have laid this beach bare along the precipitous drift cliff, extending 70 or 80 yards from the bridge (1, see Photo.) up Saltburn Beck, where it abruptly comes to an end. In baring and altering this cliff evidences of ancient kitchen middens, which once existed, have been completely effaced.

Last year Mr. Teall, Mr. Howell, and myself, jointly examined the beach, and shortly afterwards Mr. Barrow, Mr. L. Giers, and I extended the inspection. On the south of the beck referred to, there is an isolated conical hill, named Cat Nab, well-known to all who have visited Saltburn, and is a physiographical problem in itself. We searched this hill for a continuation of the beach, but being so completely overgrown and covered with soil, it was difficult to trace. The characteristic shells showing themselves at the expected horizon, satisfied us as to its existence there (2). The west side shows a clear section of drift owing to the undermining action of Brotton Beck, but no trace of the beach exists there (3), not having been deposited so far inland. Continuing the search towards Huntcliff it was again recognised at the same level (4). Here and there in it are dark looking patches containing sea-coal, similar to deposits frequently left in patches on the sea-beach of to-day. The existence of this raised beach at Saltburn only, on this part of the coast,

indicates the extremely slow denuding action carried on at Saltburn. The rate of the sea's encroachment is trifling indeed when compared with the action of the sea upon other parts of the coast; take Robin Hood Bay for instance, where the sea's action is accurately marked, its inroad being 20 feet a year, three coast-guard flag-staffs having been washed away in 20 years, these having been placed 140 feet from the shore.

In leaving these notes for your consideration, I beg to express my thanks to T. E. Harrison, Esq., Engineer-in-Chief to the N. E. Railway, and to Chas. Harrison, Esq., for their kindness in placing, for my consultation, the numerous sections of borings, and specimens they have preserved at Newcastle.

NOTES ON THE CARBONIFEROUS ENTOMOSTRACA AND FORAMINIFERA OF THE NORTH YORKSHIRE SHALES. BY GEORGE ROBERT VINE (PL. XII.)

In a paper read before the *Geological and Polytechnic Society* on the Carboniferous Polyzoa of North Yorkshire (1881), I gave some account of the shales supplied to me by the late Mr. John Harker, of Richmond. In that paper I referred briefly to the Entomostraca and Foraminifera of the shales, and also to the unnamed series in Mr. Harker's private collection. I am not certain whether previous to our acquaintance Mr. Harker had made any great progress in his investigations, for as these organisms were his own speciality we did not have a very free correspondence respecting them. One of the conditions of our exchanges, was, that in searching the shales, I promised to give him specimens of all the Ostracoda and Foraminifera found in them, a condition I was bound in honour to respect, and had he lived, this paper would have remained unpublished. In return I had his promise of duplicates of his findings, whether Foraminifera, Ostracoda, or Polyzoa. On one occasion I asked him

to give me the localities of his shales, but this I have never received; but in one of his letters, he says that his best locality was about ten miles from Richmond; but there were other localities, though not so rich in organic forms, which he promised to search for me. Had he lived, we should have worked together, as he promised me that I should have the material properly labled. As it is, my box of black muddy shale washings are marked only "Hurst," Richmond, a locality that I can give no other information of than this respecting it.* If, therefore, my northern friends would do their best to communicate to me the whereabouts of these shales, I shall be glad to give in return for their interest in my studies, something at least of corresponding value to assist them in theirs. Besides the shales, I have a few mounted forms given to me by way of exchange, and these are marked "Downholm" and "Ten Fathom Grit." These are some of the rarer species, specimens of which, however, are found also in the shales marked "Hurst." In Prof. T. Rupert Jones and Mr. James W. Kirkby's paper on *Palæozoic Bivalved Entomostraca*, No. VII., *Ann. and Mag. of Nat. Hist.*, July, 1866; the authors (p. 9) speak of a collection submitted to them by Mr. J. H. Barrow, M.A., of Settle, Yorkshire. I do not know the extent of that collection, and I am not aware that there are any more extensive references to the Carboniferous Ostracoda of North Yorkshire than are found in the various Carboniferous papers of these authors. In T. Rupert Jones' paper on the *Permian Ostracoda (Perm. Foss.*, by W. King, pp. 58–66), references are made to findings in the Yorkshire Permian rocks; and in Mr. T. Kirkby's paper on the *Permian Beds of South Yorkshire (Quart. Jour. Geol. Soc.*, March, 1865), the author refers to five species of Entomostraca found in the Shell Limestone, and in his remarks on the Permian fauna, Mr. Kirkby says, that four of the Entomostraca are German, and one, *Kirkbya Permiana*, J. and K. have Russian varieties. Since these papers were written, the ranges of several of the Permian forms are proved to be Carboniferous "recurrents," and our knowledge of the range in Carboniferous times of some of the

* Mr. Wood, of Richmond supplied to Mr. Brady for his *Monograph* on Foraminifera, material from Hurst.

species have been considerably enlarged by the discoveries of Mr. John Young, of the Hunterian Museum, Glasgow, and members of the *Scotch Geological Survey*. Very few, however, of the Carboniferous species range from the Silurian strata of this country. There is, therefore, very little difference in the generic character of the Permian and Carboniferous fauna of this type, but there is a considerable difference in the genera of the Carboniferous and of the Silurian eras. In the Silurian ages *Beyrichia*, *Primitia* and *Leperditia*, had a most extensive range, and there were a larger number of species of all the genera, but *Kirkbya* is very rare in the Silurian rocks. In the Carboniferous rocks these generic characteristics were reversed; *Kirkbya* were abundant, *Beyrichia* not so abundant in specific character, *Primitia* almost unknown, and *Leperditia* likewise few in number. It is impossible to make an exact comparison, because all the fossils being minute and difficult to identify, except by those who give to their investigations a patient earnestness, which is, alas, far from common in our matter-of-fact age. The present paper must not be looked upon then, as the work of a specialist, or in any way exhaustive. It may be possible that specialists will detect errors in the descriptions and identifications of the species enumerated below, but as these know full-well the difficulties that have to be encountered in work of this sort, I fear their criticism less than the frown of others, who have never yet attempted special labours. I feel certain that there are earnest youths in some of our Yorkshire Geological and Microscopical Societies, who are looking out for labour of some sort in the field, and ultimately in their homes. If there be such, I recommend to them the searching for, and then the systematic study of the more minute organic forms of our Yorkshire shales, and I feel confident that they will be amply rewarded in their researches. It is in the interest of these more especially that I write this paper, at the same time, I do not undervalue the work of the specialist, and I have identified to the best of my ability, and have given such descriptions of the species found in the shales as shall merit some approval of my labour even from them. I may say that in comparing my Yorkshire specimens, though I have been careful to look up the text

of previous authors, I have been anxious also to see how far these agree with the same species found in the Northumberland, and also in the Scotch shales, a large suite of which are in my collection. In all my varied labours I am personally indebted to the continuous kindness of Mr. John Young, of Glasgow, who, on every occasion that I have sought his help by way of gift or loan of specimens, has systematically granted it, and information on all questions put to him has been unstintedly given.

With regard to the Foraminifera of these shales, I find, in reference to Mr. Henry Bowman Brady's Monograph of the Carboniferous and Permian Foraminifera,* that my labours are anticipated. In that work, Mr. Brady specially cites two localities in Yorkshire from which he received material for his work. One of these is "Hurst," Yoredale, and the other "Downholm"; the material from each locality supplied by Mr. Wood, of Richmond. I was not aware, however, that Mr. Wood had devoted any share of his attention to the more minute fossils. Before him, Phillips described a species for which he founded the genus *Endothyra*, but very little progress was made till just before, and just after, the publication of Mr. Brady's Monograph. In this work, I find that the material of Hurst and Swaledale yielded sixteen species of Foraminifera, a list of which is given further on. As with other forms, so with these, the Scotch Geologists have systematically searched their shales, and the Scotch list is, consequently, by no means inconsiderable. Though not so fortunate as Mr. Brady and others, I have been successful in my findings of Foraminifera, as well as Entomostraca, but species of either group are far from abundant. Much good material, however, may be found and catalogued, but willing hands and keen eyes must be given to the work.

CRUSTACEA.

Sub. Class Entomostraca.

Order Ostracoda.—"Minute Crustaceans having the entire body enclosed in a shell or carapace, which is composed of two valves united along the back by a membrane. The valves are capable of being closed by an adductor muscle, the insertion of which is marked

* Pal. Soc., London, 1876.

in the interior of each valve by a tubercle, pit, or group of spots, or by both spots and a pit. The branchia are attached to the posterior jaws, and there are only two or three pairs of feet, which subserve locomotion, but are not adapted for swimming." *

The Ostracoda are divided into several families, some of which are wholly made up of fossil genera, others are composed of both fossil and recent genera. They are as follows:—

Family I.—CYPRIDÆ: 12 Genera, one of which is BAIRDIA.
„ II.—CYTHERIDÆ: 17 Genera two of which contain only fossil species: THLIPSURA and CARBONIA.
„ III.—CYPRIDINADÆ: 9 Genera, three of which contain only fossil species: CYPRIDELLA, CYPRELLA, and ENTOMIS.
„ IV.—ENTOMOCONCHIDÆ: 2 Genera, one of which, ENTOMOCONCHIS, contain only fossil species.
„ V.—CONCHÆCIADÆ: 2 Genera.
„ VI.—POLYCOPIDÆ: 1 Genus.
„ VII.—CYTHERELLIDÆ: 3 Genera, two of which, CYTHERELLINA, and ÆCHMINA, contain only fossil species.
„ VIII.—LEPERDITIADÆ: 6 Genera, the whole of which contain fossil species only: LEPERDITIA, ISOCHILINA, PRIMITIA, BEYRICHIA, KIRKBYA, and MOOREA.† And the last family, so far as is at present known, contain only Palæozoic forms.

Family I. CYPRIDÆ.

Genus BAIRDIA, McCoy.

1844, Syn. Charact. Carb. Limst. Foss., Ireland.

"Carapace valves externally convex and smooth, sometimes finely pitted or spined, never ribbed or granulated. The hinge is simple, no bar or teeth similar to those of *Cythere* proper, being developed. *Bairdia* is characterised, as regards the carapace, by a somewhat similar formation of valves to that which obtains generally amongst the recent *Cyprides*, and partially in the *Candonæ*." Jones, Entomos. Cret. Formation, p. 22.‡

Professor McCoy described the genus very briefly, thus:—"shell elongate, fusiform, suddenly tapering at both ends; a very short proportion of the valve overlaps the abdominal margin."

Since these works were published a large number of recent and fossil forms have been discovered and described, and most important

* Nicholson Manual of Palæontology, Vol. I. p. 341, Ed. 1879,

† Bivalved Entomostraca, Prof. T. Rupert Jones, Monthly Microscopic Journal, Oct. 1870, Part I.

‡ Palæontographical Soc., 1849.

additions to our knowledge of the genus has been furnished by Professor G. S. Brady in the *Transactions of the Linnean* (Vol. XXVI.), and also of the *Zoological Societies* (Vol. X.) But to the Palæontological students the publication of a paper on the genus "*Bairdia*," by Professor T. Rupert Jones and Mr. Kirkby, is by far the most important. In this paper the authors give a brief history of the genus, a description of all the Carboniferous species found in Great Britain, and figures of the same (*Quart. Jour. Geol. Soc.* Nov. 1879). Altogether there are sixteen species of *Bairdia* in the Carboniferous rocks of Great Britain, two of which are doubtful.

1. BAIRDIA CURTA, McCoy.

   B. curtus, McCoy, 1844, *Syn. Char. Carb. Foss.*, p. 165.

   Cythere (Bairdia) *curta*, Jones, 1849, King's *Perm. Foss.*, p. 61, pl. XVIII., fig. 3.

   Bairdia curta, Jones & Kirkby, *Quart. Jour. Geol. Soc.*, Nov., 1879, p. 567, pl. XXVIII., figs. 1 to 8.

The examples of this species found in the shales are generally crushed, and correspond more closely with the example from Settle, given in pl. XXVIII., fig. 6, of Jones & Kirkby's paper (op. cit.) In this paper the authors state that there has been, with them, a considerable oscillation of opinion respecting this type. In their present remarks they agree to accept the type, and a pretty full description of the species is given. The examples found in the Yorkshire shales vary from about $\frac{1}{20}$ to $\frac{1}{12}$ of an inch in length.

Localities: Hurst, Richmond, Yorkshire. Localities given by J. & K. Wyebourne, Cumberland; Settle, Yorkshire: Steeraway, near Wellington, Salop.

2. BAIRDIA SUBELONGATA, Jones & Kirkby, (Pl. XII., figs. 1, and 1a.)

   B. subelongata, Jones & Kirkby, *Quart. Jour. Geol. Soc.*, Nov., 1879, pl. XXX., figs. 1, 11, and 16.

   B. subcylindinea (Munst.), Jones & Kirkby, 1867, *Trans. Geol. Soc. Glas.*, vol. II., p. 221.

   B. subcylindrica, (Munst.), Armstrong & Young's *Cat. of Carb. Foss. of Western Scotland.*

Some of the specimens found in the locality given below correspond more closely with figs. 10 and 11 of pl. XXX. of the paper cited above, except that the posterior extremity is less pointed, otherwise the general contour of the specimens is similar to that

figured by Jones & Kirkby. Another specimen shows a slight concavity on the ventral border.

The description given by the authors applies "to the more typical examples, which are always to be distinguished by their nearly straight backs, regularity of height, and well-rounded anterior ends." It is very rare, however, that the valves are found uncrushed. In the crushed specimens the posterior extremities are more pointed, a feature shown in some of the figures of the authors.

Localities: Richmond; and Limestone Shales, Hurst. Professor T. Rupert Jones and Mr. J. W. Kirkby give a very full list of the localities of this species from the Upper and Lower Limestones of Scotland, but the authors give no locality in England, and only one, Great Ormes Head, in Wales.

3? BAIRDIA HISINGERI, Munster.

Cythere hisingeri, Munster, 1830, *Jahrb. f. Mineralogie*, p. 65.

Bairdia hisingeri Jones & Kirkby, 1865, *Ann. Mag. Nat. Hist.* ser. 3., vol. XV., p. 408, pl. XX., fig. 12.

Bairdin hisingeri Jones & Kirkby, *Quart. Jour. Geol. Soc.*. Nov., 1879, pl. XXIX., figs. 4-10, p. 570, pl. XXX., fig. 12.*

This species, though present in the Yorkshire shales, is not so fine nor so common as in some of the Scottish shales. I have only four fragments of the typical form, one of which shows the peculiar muscle spot. I have figured two other examples (figs. 2 and 2a), for the purpose of comparison. They are very similar in the general contour to those figured by Jones & Kirkby (pl. XXX., figs 12 and 13, *Quar. Jour. Geol. Soc.*, Nov., 1879), which the authors consider to represent an elongate form of *B. hisingeri*. "Fig. 12 is from Campsie," J. & K.

It is rather more elongate than the Yorkshire specimen, and it is less convex in the dorsal border, but the general outline is in many respects similar. Both the figures are magnified in the same proportion, 25 diameters, so that the differences between the two specimens may be noted.

Localities: Limestone shales: Hurst, Richmond. The localities in England given by Jones & Kirkby, are from Carb. Limest., River Wansbeck, Northumberland; and Wyebourne, Cumberland.

* See paper for other Synonyms.

4. BAIRDIA PLEBEIA, Reuss. (Pl. XII., Figs. 3, 5, 5a.)

Bairdia plebeia, Reuss, 1854, Jahresbericht weltterau Gesellsch, 1854, p. 67, Fig. 5.

Bairdia plebeia, Kirkby, *Ann. Mag. Nat. Hist. Ser.* 3, vol. II., p. 324, Figs. 1 & 7.

Bairdia plebeia, Jones & Kirkby, *Quart. Jour. Geol. Soc.*, Nov. 1879.

In the last paper, several synonyms and special details are given.

The Yorkshire specimens of this form differ somewhat from the variations of the type furnished by Jones & Kirkby, in their most recent paper of the genus *Bairdia*, from the Carboniferous rocks of Britain. One of the specimens, in the pointing of the posterior extremity, makes a very near approach to some of my Scotch and Northumberland specimens of *B. submucronata* J. & K., but I think that the whole of the specimens figured, may be placed under *B. plebeia*, Reuss.

Formations: Permian and Carboniferous.

Localities: Hurst, Richmond; Messrs. Jones & Kirkby give Weardale, Durham; Wyebourne, Cumberland, and Settle, Yorkshire, as northern English localities; and they say that *B. plebeia* appears to have been the prevailing form of the genus during the upper Palæozoic periods." A large number of other localities are given by authors, both in Scotland, and a few in Wales. It is not very common, so far as I can judge, in the North Yorkshire shales.

5. BAIRDIA BREVIS, Jones & Kirkby (Pl. XII., Figs. 4a, 4a.)?

B. brevis, J. & K., 1867, *Trans. Geo. Soc.*, Glasgow, vol. II., p. 221.

B. brevis, J. & K., 1871, Armstrong & Young's *Cat. Carb. Foss. of West Scotland.*

B. brevis, J. & K., *Quart. Jour. Geo. Soc.*, November 1879, p. 575, pl. XXXI., Fig. 1 & 8.

In the last of these three papers, the authors' describe and figure, with its several variations, this delicate little species, " which, compared with its height, is the shortest species of the genus," known to them.

Localities: Hurst. The other English localities given by the authors, are Wyebourne, Cumberland; Weardale, Durham; Charterhouse, Somerset; and Scremerston, near Berwick-on-Tweed.

Family II.—CYTHERIDÆ.

Genus CYTHERE, Muller.

" Carapace closed, resembling a diminutive peach stone; valves

unequal, irregularly ovate, sub-reniform, or sub-quadrangular, rarely smooth, often punctate or rugose ; anterior hinge often has an external tubercle over the anterior tooth. The contact margin of the dorsal border of each valve, has an anterior and posterior hinge joint without a tooth and pit, or a ridge and furrow."—*Professor T. Rupert Jones.*

Species belonging to this genus are not numerous, and the specimens are very small. They are allied to undescribed forms found in the Carboniferous shales of Northumberland and Scotland. These bear MS. names by Professor T. Rupert Jones and Mr. J. W. Kirkby, whose brief notes in the *Transactions of the Geo. Soc.*, Glasgow, Vol. I., 1867, have enabled Mr. John Young, of the Hunterian Museum, and other workers, to name their specimens.

6. CYTHERE CORNIGERA, Jones & Kirkby, (Pl. XII., Figs. 9, 9a.)

This species may be easily recognised by the peculiar horn-like prolongation on the valves. In the figures, this horn-like character is not so apparent as when viewed under the microscope, because in drawing with the camera, these characters are not in one focus.

Localities: Hurst, Richmond. This is a common Scottish form in several localities.

7. CYTHERE CUNEOLA, Jones & Kirkby, (Pl. XII., Figs. 6, 6a, 7. ?)

This is a common form found in the shales. In all probability, fig. 8, may be placed with the same species.

Localities: Hurst, Richmond. Common in the Scottish shales.

There are still undescribed, two, if not three species, of *Cythera*, which, for the present, must remain in abeyance.

Fam. VIII. LEPERDITIÆDÆ.

Genus LEPERDITIA, Ronault.

This Genus was introduced, says Professor T. Rupert Jones, and instituted by M. Ronault, in 1851. "Its bivalve carapace is smooth, convex, horny in appearance, often brownish, sub-oblong, or somewhat semiovate in outline, longer than broad or high, inequilateral ; posterior half broader ; dorsal border straight, ventral border nearly semicircular."* This a very important genus, especially so for the identification in foreign localities of certain strata, and the horizons

* Monthly Micro. Journal, T. R. Jones, Oct. 1870.

in which species have been found in this country and on the continent.

8. LEPERDITIA OKENI, Munster, (Pl. XII., Fig. 10 and 10a.)
Cythere Okeni, Munster, *Jahrbuch, f. M.*, 1830.
Notes on Palæozoic Bivalved Entomos. Jones & Kirkby, *Ann. Mag. Nat. Hist.* May, 1865, and Ibid Jany. 1875.

It will be impossible for the student to understand this species and its numerous varieties without referring to these papers. The specimens found in the shales seem to be referable to this species. The authors say of this form that the *Cythere Okeni* of Munster is a "*Leperditia* with the hinged or dorsal border usually a little over half the entire length, and the free, or ventral margin boldly rounded and somewhat oblique." There seems to be no other form whose general contour is so well marked, which has so wide a range as this. It is found in Russia, Nova Scotia, Germany, Belguim, and in the Upper and Lower Carb. strata throughout the British Isles. The specimens that I have are from two horizons, one set from the Richmond shales, and the other from the Ten Fathom Grit, Downholm, Yorkshire: the last was presented to me, unnamed, by the late Mr. Harker. There is in the shales, a small variety (Pl. XII., fig. 11), referred to in Messrs. Jones & Kirkby's papers, which seems to have had a variety of names. It is magnified in the same proportions (× 25), as the larger specimens. There are several other varieties of L. Okeni given by the authors, which, are not obtainable from the shales supplied to me. Seeing that the *L. Okeni* from the Ten Fathom Grit are so fine and perfect, the carapaces of my specimens being full and unbroken, it is quite possible that other species than this may be found in the same horizons if local workers would give attention to the search. In one of their papers (*Ann. Mag. Nat. Hist.*, July, 1866, p. 9), the authors refer to a collection of Entomostraca submitted to them for examination by Mr. J. H. Barrow, M.A., of Settle, Yorkshire. It may be that other collections are still extant in the neighbourhood of these shales, if so, I shall be glad to hear of them.

Genus KIRKBYA, Jones.

The Permian species belonging to this genus were originally described by Mr. T. Rupert Jones, in King's *Permian Fossils*, pp. 64

and 66. In that work *Kirkbya Permiana* Jones, received the name of *Dithyrocaris*. Since then, the discovery of a number of species in the Carboniferous rocks have necessitated a change in the name, and the present one is instituted in honour of Mr. Kirkby, the indefatigable coadjutor, with Mr. Jones in their united labours on the Carboniferous and Permian Entomostraca especially.

"The carapace valves are flattish, thick, oblong, impressed with a sub-central pit, and raised into ridges, some concentric with the margin, associated sometimes with longitudinal riblets, or wrinkles, and often accompanied by a reticulate ornament. In shape, the valves are sub-oblong, usually higher behind than before, the extremities are more or less rounded, but one often much more obliquely than the other; the dorsal border is straight, and its ends are subacute."—T. Rupert Jones' *Monthly Micro. Jour.*, Oct. 1870.

The valves of this genus in some respects resemble those of *Beyrichia*, "but the double and sometimes threefold ventral rims, and especially the sub-central pit and longitudinal riblets, distinguish them."—*Ibid.* I have not found more than three species in the shales of Hurst, and specimens of these are rare.

9. KIRKBYA PERMIANA, Jones, (Pl. XII.. figs. 12 and 12a.)
Dithyrocaris Permiana, Jones, *Permian Foss.*, p. 66, tab. XVIII., fig. 1, *a*, *b*, *c*, *d*.

The Carboniferous specimens of this species are much finer than the Permian, and their abundance in the shales of Scotland, and even in some of the Northumberland shales, enable the investigator to study the form with much greater advantage. But, so far as my own experience enables me to give an opinion, the species are very rare in the Yorkshire shales. I have only about five specimens in my collection, and these correspond so closely with the described species that I think there can be no doubt about the identity. The specimens figured (fig. 12) though magnified the same number of diameters, is smaller than fig. 1*a* *Perm. Foss.*, pl. XVIII., but rather broader than the cast 1*d* in the same plate. Some of the Yorkshire specimens are either crushed or broken; but the general form of the valves are sufficiently characteristic to enable the student to identify the species when found.*

* Since the above was written I have found more specimens of this *Kirkbya*, but I allow the original to stand, because, from my first specimen, the figures 12 and 12a are drawn, one magnified 50, the other 25 diameters.

Localities: Hurst, Yorkshire. I have the same species from Ridesdale: and Mr. Young gives the localities of Scotland, Orchard, Robroyston, Brockley.

10. KIRKBYA UMBONATA, D'Eichwald, (Pl. XII., fig. 13.)

Beyrichia umbonata, D'Eichwald, *Bulletin Soc. Imp. Nat. Moscou* 1857, p. 312, Leth. Ross., I.-V., 1859, p. 309, VII., p. 1348. pl. LII, fig. 10. See also Jones & Kirkby's paper, *Some Carb, Ostracoda from Russia*, *Ann. Mag. Nat. Hist.*, Jan., 1875, p. 53-4.

This is a much smaller form than the other, and it is marked with a central umbo. The ventral portion of the valves are thicker, and the dorsal border shorter. It is very rare in the shales.

Localities: Hurst, Richmond; D'Eichwald gives Sloboda (Carboniferous Shales); I have it in my Ridesdale collection, and Mr. Young cites Brockley, rather rare, and Craigenglen, Scotland.

11. KIRKBYA BIPARTITA, Jones and Kirkby. (Pl. XII., Fig. 14)

Transactions of the Geol. Soc. of Glasgow, 1877.

Catalogue of Western Scot. Foss., p. 44, 1856, Brit. Assoc. Cat.

This species is likewise rare in the shales. It is smaller than even *K. umbonata* and it is marked with two umbos, or tubercles in the valves. In the Yorkshire specimen these are somewhat depressed, but still sufficiently prominent to allow of identification. It is a beautiful little form, and the valves are ornamented as in some other forms of the genus with pitted impressions.

Localities: Hurst, Richmond, Ridesdale, Northumberland, Scotland; Orchard, "A rather rare form," J. Young: and Craigenglen.

I have not found in any of the shales a single specimen of *Beyrichia* or *Entomis*. In the Scotch shales *Beyrichia* are generally distributed and *Entomis* is represented by a single species in the Carboniferous shales. The genus, however, has representatives also in the upper Silurian rocks.

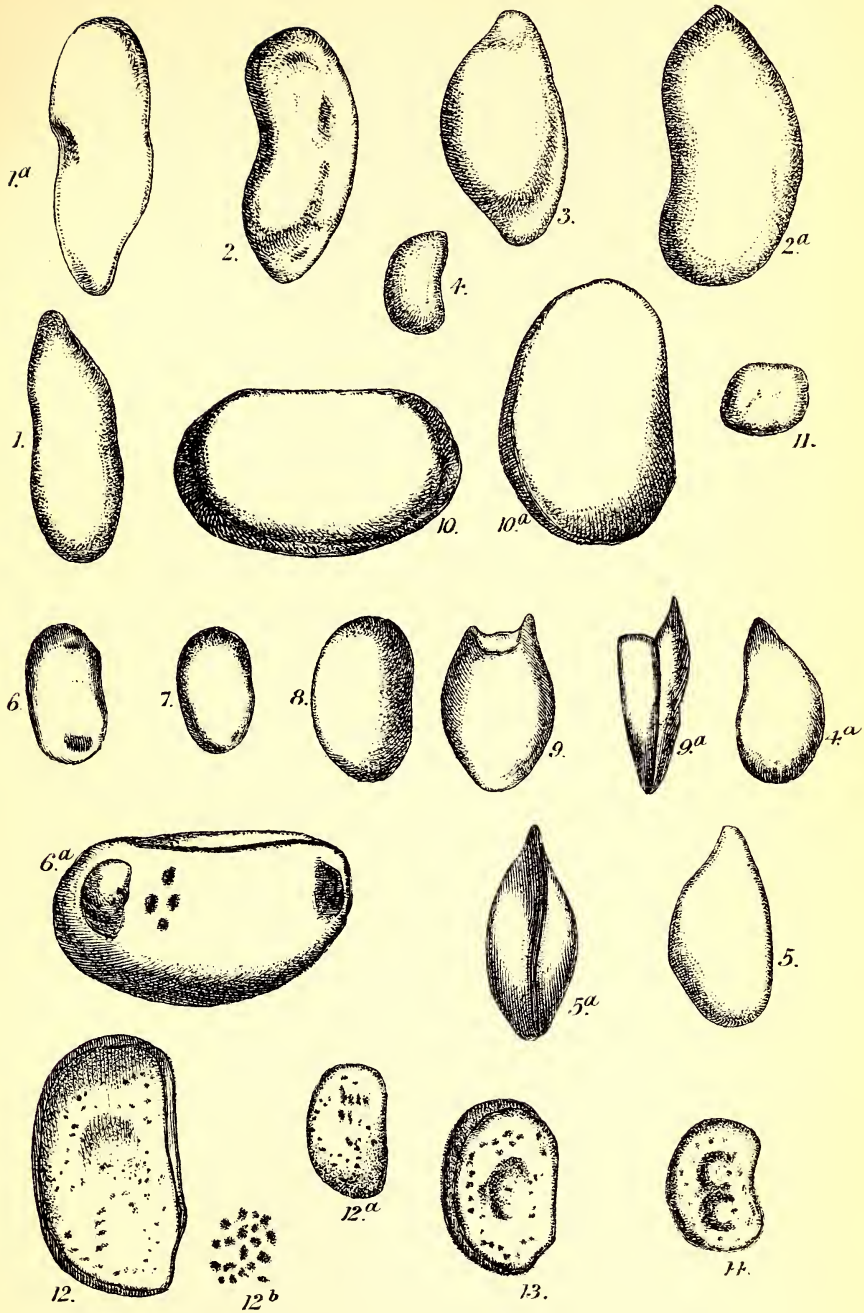
There still remains a few forms of *Ostracoda* that I am not able as yet to identify; I am not certain, but I think that some of these may be referred to the genus *Cytherella*, but for the present I leave them.

The Foraminifera of the shales has been, as I have said previously, described by Mr. H. B. Brady, but as I have some of the

forms in my collection it may be well to give a list, marking with an asterisk (*) the species found by me.

Description of Figures, Plate XII.

Fig. 1, 1*a*	Bairdia subelongata Jones & Kirkby.	×25 dia.		
2, 2*a*	„ hisingeri Munster	×25	„	
3	„ plebia Reuss....	×25	„	
4, 4*a*	„ brevis? J. & K., or var. ...	×25	„	
5	„ plebeia Reup.	×25	„	
6	Cythera cuneola Jones & Kirkby ...	×50	„	
6*a*	„ „	×100	„	
7	„ „	×50	„	
8	Cythea sp.	×50	„	
9	„ cornigera Jones & Kirkby ...	×50	„	
10, 10*a*	Leperditia Okeni Munster	×25	„	10 fathoms, Grit Downholm
11	„ „	×25	„	Small variety?
12	Kirkbya Permiana Jones	×50	„	
12*a*	„ „ „	×25	„	
13	„ umbonata D'Eichwald ...	×50	„	
14	„ bipartite Jones & Kirkby	×50	„	



YORKSHIRE ENTOMOSTRACA VINE

A. Megson & Sons, Leeds

	Hurst: —Yoredale without definite Horizon.	Hurst.	Settle.	Cumberland.	Northum'ld	Durham Carb. Limst.	Durham Yored'le
	BAIRDIA, McCoy.						
1	curta, McCoy	+	+	+			
2	subelongata, J. & K.	+					
3	hisingeri, Munst ...	+		+	+		
4	plebeia, Reuss	+	+	+		+	+
5	brevis, J. & K.	+		+		+	
	CYTHERE, Muller.						
6	cornigera, J. & K. ...	+					
7	cuneola, J. & K. ...	+			+		
	, Sp.	+					
	LEPERDITIA, Ronault.						
8	okeni, Munster	+					
8*a*	,, Small var. ...	+					
	KIRKBYA, Jones.						
9	permiana, Jones ...	+			+		
10	umbonata, D'Eichw ...	+			+		
11	bipartite, J. & K. ...	+					

FORAMINIFERA.

	Hurst & Downholm:—Yoredale without definite Horizon.	Hurst.	Downholm.
	TROCHAMMINA, Parker & Jones		
1*	centrifuga, Brady	+	+
2	anceps, Brady		+
	VALVULINA, D'Orbigny		
3*	palæotrochus, Ehrenb	+	+
4*	var. compressa, Brady	+	
5	youngi, Brady	+	
6	var. contraria, Brady	+	
	ENDOTHRYA, Phillips	+	+
7*	bowmani, Phillips	+	+
8	ammonoides, Brady	+	+
9*	globulus, D'Eichw	+	+
10*	radiata, Brady	+	+
11	macella, Brady	+	
	NODOSINELLA, Brady		
12*	concinna, Brady		+
13	linguloides, Brady	+	
	STACHEIA, Brady		
14*	marginulinoides, Brady	+	+
15*	fusiformis, Brady	+	
16*	papoides, Brady	+	+
17	acervalis, Brady	+	
18	congestre, Brady	+	+
	Not given in Brady's List—		
19*	Saccammina Carteri, Brady	+	

GLACIAL SECTIONS NEAR BRIDLINGTON. PART III. THE DRAINAGE SECTIONS. BY G. W. LAMPLUGH.

IN 1881 I described before this society, a cliff section for a short time exposed in building a new sea wall on the north side of Bridlington; and last year I undertook a similar section, lying to the south of the town.

These sections differed very considerably, and I then avowed myself unable to correlate them; but expressed a hope that I might be able to do so, by the aid of information which might be gleaned whilst drainage works were being carried out in the town. These works have now been completed, and I desire on this occasion to lay before you the results obtained.

During the progress of the work I made sketch-sections and notes of the whole length,—about $5\frac{1}{2}$ miles—and have since worked these in on the Ordnance plan of five feet to the mile; but as this is, of course, too large for publication, and there is sufficient similarity about the sections, I have reduced those which are most representative, following the main drainage lines to a horizontal scale* of eighteen inches to the mile. These will, with the aid of a few notes on the unpublished sections, I think, suffice to show the structure and arrangement of the beds.

I have also prepared a ground plan of the town and its immediate neighbourhood, which will show the levels and general run of the beds; and will help me to express my views on their origin.

The Sections. The deepest drains were those near the outfall across the harbour, where a depth of 22ft. was reached; the shallowest were about 5ft. The average depth of the drains was 10ft.

The following beds were cut through:—

Top soil, made ground and old marsh ground, sometimes of

*The length of the sections as compared with their depth, has compelled me to depart from my usual practice of drawing to natural scale, and the vertical scale is in this case exaggerated three times, a fact to be borne in mind when comparing this with former sections.

Proc. York Geol. and Polyt. Soc., N.S. Vol. VIII., Pl. XIII.

GLACIAL SECTIONS NEAR BRIDLINGTON. PART III.

THE DRAINAGE SECTIONS

SCALE.

Horizontal:- Eighteen Inches to One Mile
Vertical – X5=One Inch to Sixty Feet (same scale as in Pts I & II.)

Fig I Section from the Harbour at Bridlington Quay, across Clough Bridge, through Queen Street and along Promenade & Flamboro' Road to the Railway Arch.

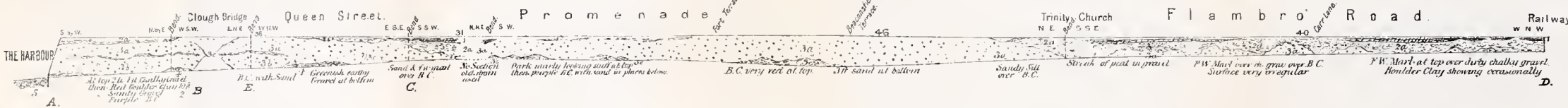


Fig II. Section from corner of Queen Street, Bridlington Quay, along Quay Road and Saint Johns Street, to corner of High Street, Bridlington

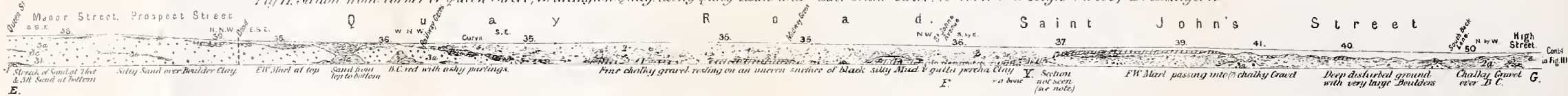


Fig III (continuation of Fig 2.) Kirkgate, to top of Pinfold St, Bridlington

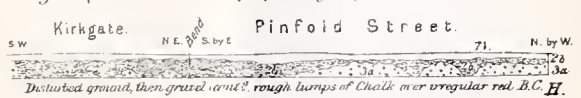


Fig IV. Section along Hilderthorpe Road to corner of Clough Bridge.

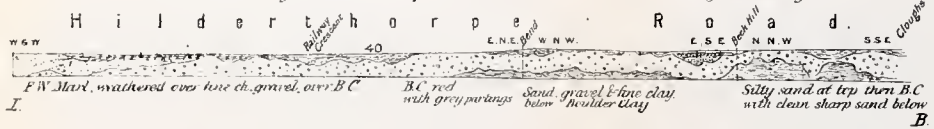


Fig V. Section from Quay Road through St. John's Avenue, St. John's Walk, Ings Lane, South Back Lane and Westgate to the top of Market Place, Bridlington.

EXPLANATION.

Top Soil and Made Ground.
1 Fresh water Marls = No 1 of Pts I & II
2 The "Gypsey Gravel" (recent fresh water) = No 2 of Pt II Fig 2.
2a Low level Sand, Gravel and Silt = No 2 of Pt I & No 2 of Pt II Fig 1(3)
2b High Level Gravel = No 2a of Pt II & Scarrby Gravel of Pt I I.p. } "The Bridlington Series"
3a. Upper Purple Boulder Clay = No 3a. of Pts I & II.
3c Intercalary Sand & Gravel = No 2a of Pt I & 3c of Pt II
3b. Lower Purple Boulder Clay = No 3b of Pts I & II.
4. Laminated Clay of Pts I & II absent from these Sections.
5. Basement Boulder Clay = No 5 of Pts I & II.

The small figures above the Sections are levels of Surface in feet above Ordnance Datum.
The large Capitals refer to points marked on Ground Plan and in text.

A. Megson & Sons, Lithrs, Leeds.

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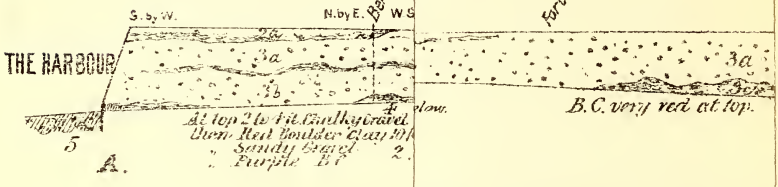

may, along Quay Road ar

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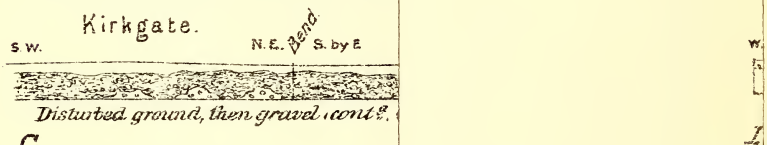
Fig. III (continuation of Fig.



Ing's Walk, Ings Lane, Sou

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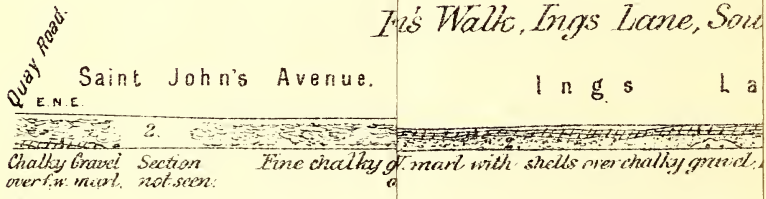

EXPLANA

Top Soil and
1. Fresh water M
2. The "Gypsey G
2a. Low level Sa
2b. High Level Gr

Drift Series"

3a. Upper Purple (
3c. Intercalary Su
3b. Lower Purple B
4. Laminated Cla
5. Basement Boul

considerable thickness in the more ancient parts of the town: 7ft. in Church Green.

1 *and* 2. Fresh-water marls (1); sands and gravels—*the Gypsey Gravel* (2). The fine chalky gravel, No. 2 of this section, seems to be roughly contemporaneous with, at least, some part of the fresh-water marls.

2*a*. Gravel, sand and silt; older than the fresh-water marls, but closely connected with them, and certainly of fresh-water origin.

2*b*. High level gravel, sand and silt; this I believe to be also of fresh-water origin, and equivalent of the *Sewerby Gravels* of Mr. Dakyns, on the north of the town; and the *Hilderthorpe Sands*, Phillip's *Warp Series*, on the south.

It is with these gravels, 2, 2*a*, and 2*b*, that I would specially deal in this paper.

3*a*. Upper Purple (?) Boulder Clay.

3*b*. Intermittent Sand and Gravel.

3*c*. Lower Purple Boulder Clay.

These beds are of the same character as in the former sections.

4. *(Laminated Clay of Parts I. and II. absent).*

5. 'Basement' Boulder Clay; only cut into for a short distance in the deepest drains towards the Harbour.

Sections not figured. The following brief extract from my notes of the lines of section not included in the figures in plate I. may be of use.

Marton Road, Bridlington. Rough chalky gravel and sand, 2*b*, over Boulder Clay with irregular surface; Boulder Clay comes to top in places. Depth 6ft.

Nungate, Bridlington. Silty sand at top, then chalky gravel resting on a very irregular surface of Boulder clay; depth about 9ft.

South Back Lane, Bridlington. At top, deep soil with broken bones, over chalky gravel, over Red Boulder clay; about 8ft.

Church Green, Bridlington. Deep black humus with sticks and bones (?) over chalky gravel. The humus, a kind of disturbed earth, but towards the bottom seems to be stratified; probably an old bog; 9ft.

Wellington Road to Promenade, Bridlington Quay. In Wellington

Road, clayey sand with gravel streaks, sometimes to bottom. 12-14ft., but often on boulder clay; beyond Tenny Lane, red boulder clay with ashy partings comes to surface; approaching Promenade, fresh-water marl and gravelly sand come on above; 6 to 14ft.

Carr Lane and Sewerby Crescent, Bridlington Quay. Fresh-water marl intermittent, over chalky gravel; over boulder clay in places; 4 to 10ft.

Chapel Street, Bridlington Quay. Boulder clay generally to top, but a few hollows filled with marly wash; about 10ft.

Grundale Terrace, Hilderthorpe. Fine chalky gravel with sand, over boulder clay; about 7ft.

Detailed Description. Commencing at the top, a noteworthy feature in certain places, especially in the old town of Bridlington; in the neighbourhood of the church, where an old priory once stood, is the depth of the top soil and disturbed ground, consisting of black vegetable humus with many fragmentary bones apparently of domestic animals. This has evidently formed an old marsh in wet times; and in Saint John Street, at the point marked Z on the ground plan, a number of big drift-boulders were found, which seem to have formed stepping stones. In other places, rough pavements made of similar material were cut through; and in Westgate, an old road was uncovered three feet below the present surface; it was overlaid by 18 inches of silty marl.

The Fresh-water Marls (No. 1). These marls occupy the low-lying parts of the town, and do not occur at higher elevations than about 40ft. above the Ordnance Datum line, though there is occasionally a loose silty wash above the lower beds at slightly higher levels. This wash probably indicates the margin of the shallow lake in which the marls were formed, whose borders would, from the character of the underlying beds, be subject to great fluctuations according to season.

In the sections between Bridlington and Quay the marls seem to pass into, or under,* the fine chalky gravel, No. 2, which reaches

* This point is left doubtful by an unfortunate hiatus in my sections, a few yards of trench near Y in Plate I. Fig. 2, having been filled in before I could examine it; the contractor informed me the marl here *rose* from the bottom of the drain, as shown by the dotted lines, but I do not feel certain on the matter.

down to the banks of the Gypsey Race, and forms a valley-gravel extending for some distance on both sides of that stream.

This gravel may be traced along the bottom of the valley in following the stream up into the Wolds,* being especially well developed at Boynton, about two miles west of Bridlington. It is everywhere far wider and reaches higher levels than is possible for the present water. The same chalky gravel appears to show in the the cliff section south of Bridlington, as described and figured in part II. of this paper. (Fig. 2.)

I should say the formation of this gravel went on simultaneously with that of the marls, so that they are on the whole roughly contemporaneous. There is confirmatory evidence of this, in that the marls generally have a thin sprinkling of small chalky pebbles in them.

The Low-level Sand, Gravel and Silt. (2a.) Where the marls exist, they occasionally rest directly on the Purple Boulder Clay if that uneven bed comes near the surface; but oftener they are underlaid by the beds marked *2a* in the sections. These are decidedly older than the marls, but closely connected with them, and undoubtedly of fresh-water origin. They vary in character, but often take the form of sandy or silty gravel with much chalk in small sub-angular fragments. Their junction with the Purple Clay often shows the peculiarities noticed in the two former parts of this paper, the clay intruding into the gravel in long 'tongues.'†

Near Trinity Church patches of peaty stuff occurred in this gravel, and I have also the skull and horn cores of a sheep (?) said to have been obtained from it.

The High-level Gravel, Sand and Silt. (2b.) On the boulder-clay slopes of Old Bridlington the low-level gravel, *2a*, seems to rise and pass, without break, into a very rough gravel of rather

* See Mr. C. Fox Strangways in Survey Memoir "On Oolitic and Cretaceous Rocks South of Scarbro'," p. 37, for account of Wold Valley Gravels.

† See also Mr. J. R. Mortimer in "Sections of Drift in Drainage Works, at Driffield" (Proc. Yorks. Geol. and Polyt. Soc., 1881), for similar appearances there.

similar lithological character, which, from its position, appearance, and direction, I should say represents the high-level "Sewerby Gravels" of Mr. Dakyns.*

The distribution of this gravel is very irregular, but it is rarely absent from the sections which rise above the 50ft. contour line. It varies considerably in roughness, being, in places, full of large sub-angular lumps of chalk such as one might find in the bed of a swift stream; whilst in others the pebbles are small, though never very well rounded. Speaking generally, its roughness increases very rapidly as we pass up the slopes on the north side of Bridlington, and decreases in the opposite direction, becoming, at the same time more sandy; from which I should infer that the bare chalk slopes in the immediate neighbourhood have supplied the chalk contained in it.

The eastern extension of the gravel towards Sewerby is not well marked till we reach the ground shown in the north-east corner of the ground plan; but from this point it may be traced continuously. There is a good section in a gravel pit behind the farm known as *Sands House*, where the gravel is very coarse and contains many large foreign pebbles, as well as much chalk, the former being no doubt derived from the erosion of the Purple Clay on which the gravel rests.

Still going east we had another fine section of the gravel in the ballast-pit in the railway cutting near Sewerby Gate-house, but this is now closed and the banks sloped. The bare chalk surface is seen in the cutting about 500 yards further north, and the gravel seems to pass down from this, and overlap the feather-edge of the Purple Clay. The gravel here forms a well-defined ridge running east and west, and must be of considerable thickness. From this point the surface slopes gradually down to the cliff, where the gravels are seen in continuous section.† They may be traced along the headland towards Flambro' Dykes, thinning out rapidly and decreasing in roughness, and finally disappearing from the cliff two

* Mr. J. R. Dakyns, Proc. Yorks. Geol. and Polyt. Soc., 1879, p. 123, and 1880, p. 246.

† See Mr. J. R. Dakyns, in papers cited above.

fields west of the Dykes Farm. They appear to die out against or thin out over, a gravel containing very little chalk.

In tracing the gravels either eastward in this direction, or southward through the town in the drainage sections, the way in which they gradually decrease in roughness as we leave the exposed chalk surface is very noticeable, and I would again call attention to it.

The bearing of these facts I shall consider in the concluding portion of this paper, in dealing with the gravels as a whole.

The Purple Boulder Clay. The description of this clay given in part II of this paper would apply to its character in these sections also. It occurs in two well-marked divisions separated by a very irregular and intermittent bed of sand or sandy gravel *(3c)*. The upper part *(3a)* in many of the sections showed all the characteristics of the "Hessle Clay" of Mr. S. V. Wood, being quite red in colour and having ashy coloured partings down its joint planes, evidently the result of weathering; but whether it is really the same as the top red Boulder Clay of Holderness, and of Flambro' Head, I have not yet been able to determine. Of one thing I am certain, that this upper division in the town is the same as that marked 3*a* in the cliff sections already published; which has always been considered as the Purple Boulder Clay.

The intercalary sand and gravel, which rose in some of the sections to a considerable thickness for a short distance but always rapidly sank and thinned again, seems to have suffered great erosion, and to have been cut down into and often completely removed during the formation of the overlying Boulder Clay. It consists in some places of pure sand, in others of roughish gravel, but oftener an admixture of sand and gravel.

I consider it to be the same bed as the gravel in the cliff section to the north (marked 2*a* in part I), and as the stratified band with intermittent sand to the south of the town (marked 3*c* in part II. of this paper).

The lower division of the Purple Clay requires no special comment, being identical in character with that of the sections already described.

The Basement Boulder Clay. This division was only touched in the deepest drains just before reaching the Harbour, but was cut into in carrying the outfall pipes across the Harbour and over the South Sands to low-water mark. It was of the same patchy nature as in the former sections, the cuttings in the Harbour showing a large proportion of sandy wash in irregular masses, not however, containing shells, save as worn fragments.

The Laminated Clay, No. 4 of former sections, true to its rule of not attempting to rise above a certain level—that of high tide—was not found in these sections, except on the beach.

Concluding Notes.—Following the plan of my former papers, I will now briefly record the deductions I have drawn from the facts observed: also as in former years, concentrating attention chiefly on one point, which on this occasion shall be *The Freshwater Gravels.*

I commenced working on the Sewerby Gravels, as on the Hilderthorpe Sands, with the idea that they were marine, but during the course of my investigations the conclusion has been forced upon me that they are freshwater; and the knowledge gathered from the drains has strengthened me in this view.

In the absence of contemporaneous organic remains in either bed there is no direct proof of this, but the indirect evidence is strong.

Before dealing with this, it will be well to show on what grounds I conclude that the Sewerby Gravels, the Bridlington High-level Gravels, and the Hilderthorpe Sands are lateral extensions of one and the same bed.

The connection between the Bridlington and Sewerby Gravels has already been partially traced. Their general appearance; their respective positions relative to the Boulder Clay and Chalk; the levels at which they occur; the character of the Chalk-fragments contained in them; and the way their pebbles decrease in size as we leave the steep chalk slopes, are all strong proofs of their intimate relationship; and that the Hilderthorpe Sands form their southerly extension rests on evidence equally convincing.

The relative position of the Sands to the Boulder Clay below, and to the marls and fine chalky-gravel above; the tendency of the sands and clays to pass into, or include streaks of gravel with small

flat pebbles of chalk; the rapid attenuation of the series southward, and its tendency to become finer in that direction, so that at Wilsthorpe only a few feet of finely-bedded warp-clay is seen; the fact that an actual passage from sandy-gravel to sand can be seen in the cliff immediately south of the town (as shown in Part II., Fig. 1, at C.), taken in connection with the strong tendency of the Sewerby and Bridlington Gravels to change into finer material as we leave the chalk, satisfies me on this point.

And there is yet the additional evidence of the isolated outliers standing out here and there above the level of the freshwater marls and lower gravels, forming as it were, detached links of the once continuous chain. One such link is the oblong knoll of sandy gravel (marked Y on the ground-plan) near where the Gypsey Race passes under the railway; another, the silty sand deposited on the crest of the Boulder Clay slope on which Belle Vue Terrace stands; and others in the broken ridge of sand in Hilderthorpe. There is abundant proof that these beds have suffered severe erosion during the deposition of the later gravels;* and from the character both of the Low-level gravel ($2a$), and the more recent stream-gravel (2) I should say that these are, more or less, re-arrangements of the older series.

My view of the origin of all these gravels is, that they are the product of fresh-water issuing chiefly from the Main Wold Valley, which debouches into the low ground of Holderness, close to the town of Bridlington, as may be seen by the contour lines on the ground-plan.

Without entering into many details of the physical features of the district, which I shall presume to be known to those who will find matter to interest them in this paper, I may explain that this valley reaches right into the very heart of the Wolds, and, with its branches and feeders, has a drainage area of about 86 square miles.† Its course upward from Bridlington to Rudstone, a distance of about 6 miles, is nearly due west, but here the main valley swerves round to the north, pursuing that direction for 3 miles, as far as North Burton, where it again curves west, continuing on the whole

* See last year's paper. † A rough estimate only.

in this direction to its head beyond Helperthorpe, a total length of about 21 miles. The hills which surround it rise to a height of from 200 to 600 feet above the sea level.

Nearly the whole of its drainage area is bare chalk, and the porous nature of that rock which absorbs all the rain that falls on it and prevents surface drainage, causes the quantity of water now coming down the valley to be extremely insignificant. The upper half of the valley is practically dry; whilst the stream, the Gypsey Race, which commences at Wold Newton and flows to Bridlington is, in ordinary winters, a mere brook, and in dry seasons ceases to flow at all.

But that this has not always been the condition of things is clearly shown, not only by the thick and widespread gravels which now cover the bottom of the valley, but, indeed, by the very fact that there is a valley at all, for its features show that it must be in some degree the result of running water, and at present there is absolutely no erosion (save chemical) going on in it, the Gypsey now everywhere flowing over its old gravel and nowhere over bare chalk, the water in it barely sufficing to keep its own channel clear. Yet if we could imagine that, from one cause or another, the surface of the chalk were rendered impervious so as to shed the moisture descending on it, the 'dry bones' of the valley would live again; and we should, even with the present rainfall, soon have a respectable river coursing along its bottom and swooping down into the Holderness country in the open light of day, instead of, as at present passing silently underground into the sea.

At one time I was inclined to believe that the chalk might have been rendered impervious during glacial times by a waterproof covering of drift-clays, of which it might since have been denuded. But the evidence for the passage of ice over the higher Wolds is so slight, and on the other hand, the proofs of an ice-flow, glacier or floating ice, skirting the coast, partially over-riding the headland of Flambro', and then passing along the inner edge of the Wold, are so strong, that I am now disinclined to entertain any view which necessitates the complete submergence of the district beneath land-ice.

And another possible explanation has occurred to me, which is plausible enough for our purpose, and enables us to dispense with the services of the dubious ice sheet.

It is this.

Though chalk when dry and open can swallow any amount of water, yet when saturated and frozen, and its joints choked with ice, it sheds water freely, as may occasionally be seen during melting of the snow on the Wolds. And if, during late glacial times the chalk were not buried beneath the ice, we may be sure it would not escape the effects of the prevalent low temperature, so that the above-mentioned conditions would not be wanting. Therefore we may, if we like, assume a more or less impervious subsoil of frozen chalk over the whole of the Wold area; and thus, with the aid of the wet weather always allowed to theorists about this time, obtain a volume of fresh water in the valley amply sufficient for our requirements.

The origin of the Wold dales and the occasional presence of terraced gravels along their flanks may be brought under the direct action of the same agency.

Now let us return to the mouth of the valley, and consider the effect of the altered conditions there.

From the head of the valley to its embouchure at Bridlington, there is a steady and tolerably steep gradient, but when once the chalk slopes are passed, and the northern end of the Holderness district fairly entered, the fall is absolutely lost, and there is at present drift ground actually higher than the valley bottom, between it and the sea. The present stream has cut through this, and thus formed the deep channel which separates Bridlington Quay from Hilderthorpe, by this means reaching the harbour. This channel has evidently been cut quite recently, as the stream now flows for the last half mile of its course through a mere trench in a ridge of boulder clay, and abandons its old gravel-flat near the corner of Piercy Lane. This gravel, marking out the old course of the drainage, is deflected to the south west, as shown on the ground-plan, and spreads out, often covered by the later marls and peat, over the whole of the low-lying ground in the neighbourhood of Bessingby and Wilsthorpe, its outer edge reaching the cliff near Auburn as

shown in Fig. 2 of last years sections. Thence its extension southward may be traced past Fraisthorpe to Barmston, where it seems to leave the coast; and, still hugging, more or less closely, the inner edge of the Wolds, pass inland by Ulrome and Beeford, the waters at that period probably finally discharging themselves like the rest of the drainage of East Yorkshire, into the Humber Estuary.

This seems to have been the course of the Gypsey water during the comparatively recent times indicated by the fine chalky gravel No. 2 of the sections. At this time the head issuing from the wolds was great enough to carry the flood over a country almost level, the fall between Bridlington and the Humber not being more than about 25ft., though the level of the land may have stood somewhat higher at that time. But as the volume of water decreased, so that circulation through a wide spread body of shallow water could no longer be sustained, marls and peats commenced to form in the lower portions of the flooded country, in part contemporaneously with the gravels in the direct streamway, and their deposition, in some places, did not cease till the time of artificial drainage in Holderness.

Prior to the period of this, the "Gypsey Gravel," the stream from the mouth of the valley seems to have been strong enough to penetrate further east before being deflected, sweeping past old Bridlington but curving round southward before reaching Sewerby, its outer limits and curve being nearly coincident with the 50ft. contour line. Higher ground standing where now the sea is, a continuation south-eastward of Potters Hill, perhaps, seems then to have deflected the stream along a course nearly due south, causing it to pass to what is now the seaward of Bridlington Quay, and then south-eastward across towards Auburn, and so inland, as indicated in part by the dotted lines in the plan. The stream would thus sweep round the knoll of boulder clay on which the Quay stands; and evidence of its course is found in the gravel *(No. 2 of Part I)*, whose feather edge may be traced along the top of the North Cliff into the town. Towards the harbour this thickens considerably; and I think that where the harbour now stands, once formed part of the hollow, containing gravel and freshwater marl, which is seen in the cliff

section just beyond the South Pier (shown in Part II., fig. 1); and in this way there may have been a connection with the similar hollow seen in section near Sands Cottage on the north of the town.

It is thus that I would account for *the low level gravels*, 2*a*, of the sections.

There remains now to be considered the high-level series of Bridlington and Sewerby, with their supposed extension, the Hilderthorpe Sands.

We may safely assume that the formation of these beds followed very closely on glacial times, if indeed, not themselves actually glacial, for it is an open question whether they were not, in part at least, contemporaneous with the Boulder Clay.* This allows us as the period for their formation the time of storms and melting ice, when the yield of water from the valley would attain its maximum, and the whole of the low country might be flooded to a considerable depth; for the dam of Glacial Clays across the mouth of the valley at that time reached higher levels than at present in its extension seaward, and not only stemmed back the flood, but also may have diverted into it part of the drainage of the Bempton Valley.

The effect of this would be to create a wide lake with strong currents, between the Wold slope and the coastwise glacial bar, in which the swift flood-waters, stayed in their course, would rapidly throw down their burden in the order that we find it, the rough sub-angular gravels at the lower levels near the mouth of the valley where the torrent was first stayed *(the Bridlington Gravels)*, the smaller gravel carried forward and banked against the gentle slopes of Boulder Clay at the curve† *(the Sewerby Gravels)*, and the finer material deposited from the eddying waters after sweeping into the lake,‡ as crossbedded and ripple-marked sands and warps *(the Hilderthorpe Sands)*.

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* Mr. J. R. Dakyns supra. cit.

† For the supposed effect of the ice-laden currents on the slopes near the curve, see conclusion to Part I. of this paper in *Yorks. Geol. and Polyt. Soc.*, 1881, p. 395, et seq.

‡ I should expect the same results if the level of the sea at this time stood high enough to form an estuary at this spot, but the evidence is against the sea being higher than at present and favours the view that it was lower.

I am by no means certain that the ice which formed the top red clay of Flambro' Head had entirely disappeared at this time. Indeed, I am inclined to think that its presence as a glacier overlapping the headland and stretching into Bridlington Bay may have aided in the deflection of the valley-floods, and have also helped to swell them, not only by waters poured down the Bempton Valley, but also by streams issuing directly from the ice and coursing south-west. In support of this I would cite the chalkless gravel which is seen to pass under the Sewerby Gravel in the cliff section opposite Sewerby Park, and the similar gravels seen in many places on The Head, which are evidently the result of the washing of Boulder Clay material. I am inclined to think the gravel, 2*b* of Part II., is of the same age as these chalkless gravels and has had a similar origin.

I think the term "*Bridlington Series*" might fitly be applied to cover the Bridlington and Sewerby Gravels and the Hilderthorpe Sands, to include also the low level gravels marked 2*a* in these sections, whose formation is so analogous to that of the older beds, of which they probably formed a direct continuation in time, that it is not necessary to separate them.

I would also suggest the term *Gypsey Gravel* for the more recent gravels, No. 2 of these sections, as their history is, beyond all doubt, closely connected with that of the stream which bears the name.

In conclusion, the picture presented to my imagination of the condition of things in the neighbourhood during depositions of *the Bridlington Series*, is of bleak frozen chalk wolds, silent and deserted, and deeply covered by snow in winter, and in summer streaked and drenched with melting snow and muddy chalk *détritus*, and of dales, sometimes ice-bound, sometimes held by rills and streams and floods of icy water sweeping out into the low ground with swift floe-laden currents, submerging much of the wide uneven plain which then stretched far out into the present bed of the North Sea, and reducing it to a state resembling the descriptions we have of the Siberian *tundras* in flood time.

Later, with less copious streams, I picture Holderness as a "mershe countree;"—a place of lakes, and bogs, and ponds innumer-

able, with sluggish waters meandering amongst island knolls and ridges covered with forest trees or tangled brushwood and reeds—a place, indeed, fitly justifying the opinion of a rueful farmer of these parts, who roundly holds that "'twas never made nor meant for aught but a place to shoot wild-duck in, and it's man's own fault if he wont believe it." This condition of things I suppose to have extended up to the historic period.

This for what it is worth, for I know well enough the danger of theorising on too narrow a basis; and do not profess to have carried on a close investigation save in my own immediate neighbourhood, and therefore state my conclusions subject to the correction or confirmation of those whose work and experience are greater than mine. But, with this caution, I think no harm can come from this tentative statement of a theory which conveniently covers all the facts known to me, and I should like to hear if similar explanations could be given in other localities whose physical features resemble those of this neighbourhood.

I may mention that in considering the origin of our East Yorkshire Boulder Clays it has seemed to me that the land-ice theory only partially succeeds in explaining the facts. Not, indeed, that I have any very definite views on the subject, only, in the course of my work, I have found myself falling into the habit of thinking or speaking of this, or that, as the product of land-ice, without having a very clear notion of the properties and capabilities of that curious body.

In fact, now-a-days, an ice-sheet has become a sort of geological comfort and one can hardly do without it; but somehow, in this neighbourhood, when I have invoked its aid, it has persisted in doing the things it ought not to have done, and leaving undone the things it ought to have done in so irritating a manner that I have ceased to place much confidence in it. Of course a good glacier under perfect control in a high mountainous country is extremely serviceable and can be held accountable for much; but ice-sheets sprawling out over great flat plains, like that now occupied, save for the little corner of Holderness by the North Sea, seem to do much as they like, and refuse to give any reasonable explanation of their conduct.

Might one expect to find traces of *Kryokonite* in any of our glacial clays?

In the first part of this paper I stated my views on the subject of the intermingling of these gravels with the Purple Boulder Clay; in the second part, on the origin of the stratified band and intercalary sand and gravel in the Purple Clay; in the *Geological Magazine*, for September, 1879, I have described the Laminated Clay; in the same magazine for December, 1881, and possibly also in a forthcoming number of the *Quart. Jour. Geol. Soc.*, I have dealt with the Basement Boulder Clay and its included fragments of beds; and with the present paper it is probable that this series will close. Not from want of matter, for there are problems enough in this, as in most neighbourhoods, to suffice for many lives, but from the current of events which will separate me from my work.

I have to thank Messrs. Dobb & Gummer, the contractors for the drainage works, for the facilities and information they have so courteously rendered me during the course of the work; and J. S. Moloney, Esq., C.E., for his kind advice and aid in preparing the plan and sections.

ON THE SHELL MOUNDS OR KITCHEN MIDDENS AT SPURN POINT.

BY H. BENDELAK HEWETSON.

(Publication deferred.)

THE YOUNG STAGE OF SOME CARBONIFEROUS CEPHALOPODA

BY WM. CASH, F.G.S.

(Publication deferred.)

GROUND PLAN *(copied from Ordnance Map) showing general distribution of beds in the neighbourhood of* **BRIDLINGTON.**

Scale, Six Inches to One Mile.

EXPLANATION

Chalk – Green.

Boulder Clay – Blue.

"The Bridlington Series" – Pink.

"The Gypsey Gravel" and *Fresh water Marls* – Brown.

The red lines show the course of the Drains of which Sections were obtained.

The small numbers are levels.

The Capitals refer to places indicated in the sheet of sections or in the text.

The dotted lines show the supposed course of the Gypsey during the formation of the Bridlington Series – Red, and of the Gypsey Gravel – Brown.

The Blue lines mark sections described and figured in former papers, as under:–

1 – 1 In Proc Yorks Geol & P. Soc. for 1881 p. 383.

2 – 2 In Proc. Yorks Geol. & P. Soc. for 1882 p. 27.

3 (Exposure on Beach) in Geological Magazine for Sep.t 1879.

4 (Exposure on Beach) in forthcoming Number (?) of Quart. Journ. Geol. Soc.

NOTE. *This Plan shows the general run of the beds only, omitting the minor details – this being rendered necessary by the nature of the beds which renders it impossible to obtain sharp lines on the surface.*

BIOGRAPHICAL NOTICES OF EMINENT YORKSHIRE GEOLOGISTS.

II. "ADAM SEDGWICK." BY T. M'KENNY HUGHES, M.A., WOODWARDIAN PROFESSOR OF GEOLOGY, CAMBRIDGE.

THE story of Adam Sedgwick carries us back through years full of stirring events, to times very different from our own, whether we regard the changes of the political world or the march of scientific discovery.

In a letter written when he was an old man, he says:—"On the 22nd of this month I shall have completed my 78th year, and 78 such eventful years! I well remember the breaking up of the old monarchy of France, the death of Louis XVI., the "reign of terror," the excitement which reached every nook and corner of this island, the early struggles for the abolition of the slave trade These things stand out among the remembrances of my early boyhood. Then followed the rise of Napoleon, the falling down of kingdoms, the threat of invasion, the phantom of old England's doom, and of a despotic empire which was to be built over the graves of national liberty and christian freedom. Then came the great providential change, a victory gained over a gigantic military despotism, not by the arms of man, but by the powers of nature which are the might of God's strength in the workings of His providence. And the same years, tell us in their history, of the rise of England's most anomalous and portentous display of power in the Eastern Continent. And during the same years we have seen the rise of England's children in the New World of the far West. First breaking off from the parent stock and vindicating their national freedom; then with all the energy of their race (and with all the benefits of the political freedom of Western Europe), starting on a new road towards political strength and national greatness, and advancing on it at a speed unmatched in the past history of man.

"And the triumph of sciences have gone hand in hand with these great world-wide movements; or perhaps it would be nearer the truth to say, that science has been their main spring and living

strength. Gas-light, railroads, steamboats, and electric telegraph, are in my memory but things of yesterday. Years well remembered, were past in my early life before such things were so much as heard of; and yet how vastly they seem to have changed the whole outer world of civilized Christendom."

The Sedgwicks belonged to that fine old race of small landed proprietors, 'statesmen,' which is now, alas, so fast disappearing from even the Northern Dales. Among them the Sedgwicks held a prominent place, their names occurring in the register of Dent as far back as 1672.

In 1756 Sedgwick's father entered as an undergraduate at St. Catherine's College, in Cambridge: a serious business it was to get from Dent to Cambridge in those days. He took holy orders, returned to his native place and became vicar of Dent. And Sedgwick was born in the old vicarage, March 22nd, 1785.

His childhood was passed amongst the hearty, straightforward dalesmen, and he was a general favourite with them all. He delighted in every kind of sport and out-door exercises, and he had always a quick eye for anything curious and unusual, which he might come across in his scrambles amongst the crags and fells which surrounded the valley.

In later years he often refers to this part of his life as full of happy recollections. Writing from Dent, in 1860, to a friend, he says—"The home scenery is delicious, and glowing at this moment (6-30 a.m.) with the richest light of heaven; and from the door of this old home of my childhood, I can look down the valley and see, blue in the distance, the crests of the lake mountains which rear their heads near the top of Windermere. All around me is endeared by the sweet remembrances of early life, for here I spent my childhood and early boyhood, when my father and mother, three sisters, and three brothers were all living in this old home. Our home was humble, but we were a merry crew, and we were rich in health and rich in brotherly love."

Sedgwick's education was begun under his father's eye, in the old grammar school of Dent, and he afterwards went to the Sedburgh school, which had a high reputation, and was attended at that time by the sons of most of the leading statesmen, as well as by many

others who have made their mark in the world.

He boarded along with three other boys, at a farmhouse kept by a Quaker. "We were treated by the family," he says "with infinite kindness, and our happy freedom made us the envy of our schoolfellows." Here he gained the habit of early rising, and he kept it all through his after life, to the very last.

In 1804 Sedgwick entered Trinity College, Cambridge, and struggled amongst men, and in the battle of the brains acheived a noble position; a splendid scholar all round, but overworked, he was advised, probably he himself suggested the prescription, to be more in the open air, and see whether nature would restore the balance. So he forsook much of his classical and mathematical work, and gave his time to the study of Geology; but he was now entangled in many varied interests, and he could not give up all the academic ties. However, into this part of his history I do not now purpose to enquire. I pass over his life at Norwich, where as Canon he resided in the old cathedral close a long part of every year. Nor will I dwell upon the part he took in college and university affairs, at one time as Vice-Master of Trinity, at another as secretary to the Prince Consort, Chancellor of the University, in times of grave interest. I go on to speak of his Geological works.

The recollection of Professor Sedgwick's personal character is still bright. His influence in moulding and guiding the opinions of his time is well known; but many would be rather at a loss to say what he did directly for geology. He wrote no great text book; he was not for ever watching, for fear any one should take an idea, or copy a sentence from him without acknowledgement; he talked freely to every one, giving them results of his original observations, he once said himself, I never had a geological secret in my life. But with all this, perhaps because of this, his papers are not so generally referred to. The *presence* of the man was so great, the personality is looked back upon as so strong, that the writings are not much appealed to in forming our estimate of him.

A short sketch of some of his published works may not therefore be wholly without profit and interest for a Yorkshire audience.

When he was appointed to fill the Woodwardian chair at

Cambridge, in 1818, he modestly said he knew nothing about geology. He had not paid special attention to the subject. His studies had been classics and mathematics, in both of which he was among the first few men of his year. But we know from many sources, that he had long been an intelligent observer of geological phœnomena. As he wandered with his gun, or fishing rod, among the crags and up the streams of his native Yorkshire, he noticed the lie of the rocks and the occurrence of fossils.

It was not long, therefore, before he attacked the most difficult questions relating to the physical structure of various parts of England. He read papers on the Lizard district, before the Cambridge Philosophical Society, in 1820 and 1821, in which, among other things, we find the Metamorphic origin of the Serpentine suggested.

He published in the Annals of Philosophy a letter dated March 17, 1822, on the Geology of the Isle of Wight, in which he confirms the views of Webster where opposed to those of Sowerby.

In speaking of the green sand and chalk formation, he points out that "when the salt in the vicinity of Cambridge is perforated for the purpose of obtaining water, the first discharge forces up a quantity of green sand, a fact which indicates the existence of the green sand formation below the salt. This sand he identifies with that seen passing under the salt in Bedfordshire; points out the mixed character of the fossils in our upper green sand, and forms the classification and nomenclature of the beds round Cambridge which is still in use.

The year 1822 is a very long time ago, and many genera and species have been re-named and re-arranged since then.

In a syllabus published in 1821, for the use of his Geological class, he gives a classification of the sedimentary rocks, which holds good on all the chief points. Of course the older Palæozoic rocks had not yet been worked out. He was, himself, the first to put them in order some ten years later. In those early days the Wernerian and Huttonian theories were still subjects for difference of opinion, and many years later, referring to the Aqueous and Igneous theories, he said playfully, that for a long time he had been troubled

with water on the brain, but that light and heat had completely dissipated it. It is pleasant to read a good practical paper founded on original observation in which the character of dykes is so well discussed, as in Sedgwick's papers on the Phœnomena connected with Trap Dykes in Yorkshire and Durham. He refers them to an igneous origin, and points out that dykes are of all ages.

In describing the columnar structure it did not escape his notice that the prisms were arranged at right angles to the cooling surfaces. He mentions also the common mode of weathering into great balls by the exfoliation of successive layers from the joint faces.

He fully recognised the value of palæontological evidence. As early as 1822 we find him in a letter to the Editor of the Annals of Philosophy, stating his view of "the importance of an intimate acquaintance with certain branches of natural history. Without such knowledge," said he, "it must be impossible to ascertain the physical circumstances under which our newer strata have been deposited. To complete the zoological history of any one of these formations, many details are yet wanting."

He always carefully collected fossils and referred them to the best authorities he could find on each special group. But while he appealed to palæontological evidence, wherever he could, he recognised that the first thing was to get the rocks into the right order in the field.

In the Annals of Philosophy, for April and July, 1825, Professor Sedgwick had a paper on the Origin of Alluvial and Diluvial Formations, in which he distinguished the older formations, which we should now call drift, from the generally newer alluvial deposits. He pointed out the anomalous position and irregular distribution of the boulders, but the fact that glacial conditions once prevailed in our island and even extensive tracts all over the northern part of our hemisphere had not been recognised at that time.

At the end of the paper is an appendix, giving an account of some changes in the channels which drain the fen-land: an account full of interest to those familiar with the Humber and its tributaries and all the phænomena of silting up and warping. He concludes with this passage:—"If such extraordinary effects as those describ-

ed in this note be produced by the accumulation of alluvial matter in course of a few hundred years, we may be well assured that the whole form of the neighbouring coast must have been greatly modified by the same causes acting without interruption, and without any modifications from works of art, for 3,000 or 4,000 years."

The structure of the Cumbrian Mountains and their surrounding carboniferous margin, formed the subjects of more than one able paper. But in those early days he inclined more than he would have done in later years to the opinion of Elie de Beaumont, that the mountain chains were the result of somewhat rapid upheaval, and points out the application of the theory of the parallelism of contemporaneous mountain chains to the districts he was describing. A view pushed too far by its author, but undoubtedly having a foundation on facts. He soon extended his examination of the carboniferous rocks far over the Yorkshire moorlands.

A list of his works shows how varied the range of his enquiries was, for about this time he had read papers on the Strata of the Yorkshire Coast, on the Secondary Rocks of Scotland, and of the Isle of Arran; and, in conjunction with Murchison, published many sketches of the Geology of the Eastern Alps. At one time we find him describing the raised beaches of Devon, at another, somewhat puzzled by the newer deposits along the cliffs of Sheppey.

But among all these various notes and observations, which are of a very bright order for half-a-century ago, there are some great papers which will be always standard works. First, I would name his splendid Monographs on the Magnesian Limestone and New Red Series, written between the years 1826 and 1832. There is nothing else like them belonging to that period of Geological history. He points out the enormous unconformity at the base of the series. "After the production of the rocks of the Carboniferous order, the earth's surface appears to have been acted upon by powerful disturbing forces, which, not only in the British Isles, but throughout the greater part of the European basis, produced a series of formations of very great extent and complexity of structure. These deposits (known in our country by the name of New Red Sandstone and Red Marl, and when considered on an extensive scale comprising all the

formations between the coal-measures and the lias), notwithstanding their violent mechanical origin, have several characters in common, which enables us to connect them together, and, for general purposes of comparison, to regard them as one group." He points out the palæontological distinction between the Upper Limestones of the group (Muschelkalk) and the Lower (the Magnesian Limestone).

While attaching due weight to such a great unconformity for purposes of local classification he cautions us against pushing this kind of evidence too far. "We have no right," he says, "to assume, nor is there any reason to believe, that such disturbing forces either acted uniformly or simultaneously throughout the world. Formations which in one country are unconformable, may in another be parallel to each other, and so intimately connected as to appear the production of one epoch."

He gives the following classification in descending order :—

Upper Red Marl and Gypsum.
Upper Red Sandstone.
Grey thin-bedded Limestone.
Lower Red Marl and Gypsum.
Yellow Magnesian Limestone.
Marls and thin beds of Magnesian Limestone.
Lower Red Sandstone.

Some difficulty occurs in following the various accounts of the lowest beds of the group, but it can, I think, be easily explained. The Lower Magnesian Limestone passes down into red or yellow sandy beds at Pontefract. So in the Eden Valley the "brockram" or basement conglomerate of the Poikilitic series rests on red and yellow sandstones. But these are of totally different age. In the sandy beds of the roadside cliff near the great quarries just outside Pontefract, I have myself found Schizodus obscurus. These beds undoubtedly belong to the Magnesian Limestone Series.

In the Eden Valley, on the other hand, it was found by boring near Appleby that the red colour did not extend lower than a little over 100ft. into the rock. It was obviously a stain produced by infiltration from above. And there is in the Woodwardian Museum a collection of fossil plants from the N.W. margin of the same area from red beds formerly referred to the Poikilitic series which contain nothing but Upper Carboniferous species.

These facts obviously account for the difficulties which have arisen from some observers recording that the base of the Poikilitic series graduated into the Carboniferous, while others saw a strong discordancy between the two. The confusion has been increased by an attempt to force the English classification into harmony with the as yet unestablished sequence of Germany, or the still less known deposits of Russia.

"Each country, said Sedgwick, ought to be described without any accommodating hypothesis, according to the type after which it has been moulded. But in comparing the unconnected deposits of remote countries, we must act on an opposite principle; learning to suppress all local phœnomena, and to seize on those only which are co-extensive with the objects we attempt to classify."

Whatever therefore may be convenient in respect to the Dyas of Germany, or the Permian of Russia, all the attempts to bracket the magnesian limestone, and associated red marks *of England* with the carboniferous instead of making them the beginning of a new series, forming the base of the secondary rocks has been founded on stratigraphical mistakes and tends to perpetuate an unnatural classification.

Another great paper written about this time was that on "The Structure of large Mineral masses," which the council of the Geological Society thought advisable to publish before its turn, because they considered it to be introductory to other papers of his they had in hand on the origin and structure of the older stratified rocks.

Obviously it was of the greatest importance to point out the nature of concretionary action, and to distinguish indigenous segregation from the results of original mechanical accumulation. We are continually reminded of the value of accuracy of observation on such points even in the discussions of to-day. He goes on to examine another series of phœnomena of no less importance which on various occasions he had commented upon before. The obliteration of the evidence of original stratification by a superinduced structure known as cleavage, and the relation of these to joints. When deposits which were laid more or less horizontally have been in after ages exposed to great lateral pressure (whether due to the heaving up

of enormous piles of rocky sediment upon compressible material in adjoining areas or to the secular shrinking of the earth's crust) they yield more or less, and so every mass or particle which has or could assume a flattened form is forced to arrange itself in planes at right angles to the pressure and we get the phœnomenon of cleavage. When shrinkage sets in or strains, causing often cracks, another set of divisional plains is formed. Others besides Sedgwick, viz.:— MacCulloch, and Bakewell, and Phillips, and especially Jonathan Otley, had observed and speculated upon these cleavage, joint, and bedding planes, but it remained for Sedgwick to work the question up, and describe their manner of occurrence and relations to one another. The results of his investigation he published in this masterly work on the structure of large mineral masses. I will not attempt to give a resumé of all his work, a mere enumeration of the seventy or eighty papers written by him would take more time than I could ask you to accord me. I ask you to bear in mind that most of what I have described was done about half a century ago, and to remember what was the state of geological enquiry then. His chief work, however, was in the old Grauwacke, and I think I would not be doing justice to my hero, or my duty to the society, which has done me the honour to allow me to give this short notice of his work, if I did not, in pointing out the progress of his enquiries into the Cambrian and Silurian rocks state briefly but clearly the circumstances which led to the great controversy between him and Murchison—a controversy which from the very personal character which it in this case, almost necessarily assumed, gave a tone to much of his later work and showed through all his later life.

In 1835 he read conjointly with Murchison before the British Association a paper on "The Silurian and Cambrian Systems, exhibiting the order in which the sedimentary strata succeed each other in England and Wales." In this paper Murchison gave Ludlow, Wenlock, Carador, Llandeilo. Sedgwick described Upper, Middle, and Lower Cambrian, and further began already to speculate on the correlation of the North Wales series with the Cumbrian of the Lake District, stating that there was not sufficient evidence to allow him to say that the lowest rocks of the lake district were on the

same horizon as the lowest of Wales. He further suggested the mode of connecting Murchison's work and his own, of course he assumed that Murchison's sections were correct.

Here we find the terms Cambrian and Silurian fully recognised, and we need not refer to the mere question of nomenclature again. We have only to consider as we go on and get further evidence to what it was that each author applied his own term, and where they came in collision as to the grouping of the rocks, whose classification was true to nature.

Now what did Sedgwick mean by Cambrian previous to 1839? Following up his investigations in N. Wales he offered in 1838 a further tentative grouping which is very nearly that which must be adopted now. It is as follows in descending order :—

WALES.	LAKE DISTRICT.
Refers to Murchison's *Silurian*, as described in his papers and "forthcoming work."	*Upper Division* with no marked unconformity at the base. Flags, quartzose, greywacke, coarse slates with imperfect clevage.
III. UPPER CAMBRIAN.	
From the base of the Grits which = Caradoc of Murchison to Bala Limestone. [We shall see that Murchison's then called Caradoc was the May Hill S., not what Murchison and the Survey afterwards called Caradoc].	Lower part, Slates based on Calc Slates passing into Limestone (Coniston Limestone). [This part is a little obscure in consequence of his not having yet made out the true position of the Ireleth Slates].
II. LOWER CAMBRIAN.	
The Volcanic Series of Snowdon, Glide Fawr., &c.	Slates, compact felspar, felspar porphyry, and brecciated porphyries.
I. [He does not yet give a name to these.]	
The older Slates and Quartzites of Anglesea and Carnarvonshire.	Nothing to show that this group is analogous to that of Skiddaw.

He quotes Murchison's Llandeilo Flagstones and Caradoc.

He did not add much to the above in his paper read before the Geological Society, in 1841, but now the "Silurian system" had been published, and the difficulty of making his work agree with Murchison's sections was evidently increasing.

In June, 1843, he offered some further notes on N. Wales, and still finding no organic remains in the oldest and generally most highly metamorphosed rocks, did not very clearly define their age, but placed them correctly at the base of the whole series. He now

seemed to avoid questions of nomenclature, but we have no difficulty in making out what the rocks were that he referred to under the head of Middle Division of the Cambrian Slates, as he gives a good list of fossils which shows them to be the well-known Bala Beds of our modern terminology. In November of the same year, he wrote a fuller paper on the Palæozoic (Protozoic) Rocks of N. Wales, in which he gives some further sub-divisions, and fuller descriptions of sections across the country.

There is some difficulty in following the palæontological evidence in the absence of figures, as more knowledge has called for closer discrimination in the species and genera, and many names have been changed since those days, as may be seen by reference, for instance, to the Silurian system, where the excellent figures enable one to determine at once what species was intended. Therefore, it is probable that when, for example, we read of Asaphus (Ogygia) Buchii being found about the horizon of the Arenig rocks, it was probably Ogygia scutatrix or peltata, and so on for many others. However, we have here a clear sequence given in the Cambriam Rocks. The Arenig slaty beds overlaid by the porphyritic series, and this by various divisions clearly belonging to the Bala Beds.

We see clearly enough what he meant by Cambrian, viz., every rock that could be made out to follow in conformable succession below the Sandstones at the base of the Denbigh Flags. He left somewhat doubtful many of the metamorphic rocks of Anglesea and Carnarvonshire. He had not yet clearly correlated the rocks of N. Wales with those of the Lake District, and he felt that as he proceeded south there was much difficulty in making his sections agree with those of Murchison, but his series was clear, as shown in the vertical section.

In the latter part of this paper (will it be believed?) the nomenclature used by Sedgwick was altered in the proof-sheets by Warburton, in order to bring it into accord with the now more favoured terminology of Murchison. Altered without Sedgwick's consent. This statement has been made over and over again and never contradicted.

In 1843 he filled in some details but made no change in the order of succession. The following series shows what he included in his Bala beds.

a. Slates W. of Areing, with a large trilobite, like Asaphus (Ogygia) Buchii? O. peltata.

b. Slates with interbedded volcanic ejectamenta.

c. Dark earthy slates, with Trinucleus Caractai (= T. concentricus), Asaphus Powisii, Leptæna sericea, encrinites, &c.

d'd''. Shales with subordinate Limestone, *d'*, from which he gives very full lists of fossils.

Then follow other shales, *d'''*, and above them the Hirnant Limestone, *e*, the true relations of which I hope to describe elsewhere.

Many of Sedgwick's old sections, which he exhibited when these papers were read are still in existence, and represent what is found recorded in the published papers. They can be compared with the Survey sections. It will be seen that the Survey has drawn no lines not pointed out by Sedgwick, and when it has indicated by letter the occurrence of formations not mapped, it will be seen that Sedgwick had suggested their separate existence long before.

Take the section from Trawsfynydd to Cynicht. It was made in 1846 from Sedgwick's much earlier notes. His papers of 1838 give the sequence, and from a comparison of this with the Survey section (28, C and D), it will be seen that they adopted all his classifications. This section is taken across the typical district from which later he named the whole of the Lingula flags, the Ffestiniog group.

In other sections described in his papers, he gives the Lingula beds, the Pisolitic iron-ore beds, *i.e.* Arenig and the overlying slates, all of which are mentioned in the text under the head of Cambrian.

The section from Pentrevoclas to Abergele shows the grits which Sedgwick took as the base of the Silurian, below which he supposed the unconformity to occur, which he mentioned in his paper before the Geological Society, above quoted.

The Survey did not set aside but confirmed Sedgwick's classification over all N. Wales. Where was the difficulty? Why, in

trying to make these sections fit on to Murchison's, which were utterly wrong.

Let us now consider what Murchison's grouping was, and on what founded. We will go to Llandeilo to see what he meant by Llandeilo rocks. The beds to the west of Llandeilo were changed from Cambrian to Caradoc. The Cambrian and Llandeilo had to be turned the other way up. The Caradoc on the east of the valley was changed to Llandovery.

This, however, was not so serious when we consider what was then meant by Caradoc which is quite clear from the description of it in the Silurian system and the fossils said to characterise it. See Sil. Syst., pls. 19, 20, 21, from which it will be seen that it included part of the Upper and part of the Lower Silurian. Thirteen years later, Sedgwick cleared this up in his paper on a proposed separation of the so-called Caradoc Sandstone into two distinct groups, 1, May Hill Sandstone, and 2, Caradoc Sandstone. So Murchison had not got Llandeilo or Caradoc right in his typical sections.

It would not be profitable to try to pick holes in such a fine production as the Silurian system, where the labours of Lewis, of Agmestry, and of Williams, of Llandovery, and of the author are so skilfully worked in, and the beautiful illustrations of which make it a classic work never to be set aside as useless.

But a question has to be answered in common justice.

Two prominent geologists had put forward two different and contradictory schemes, before 1839. Which of the two was right in 1839? I submit without hesitation that Sedgwick was right in 1839, and go further, I say that Sedgwick's is still the classification most true to nature.

If you look at Murchison's later works, or at the publications of the Survey, which were issued under his direction, you will find that the great stratigraphical errors mentioned above have been corrected. But how? Was it by acknowledging that he had misunderstood a local anticlinal bringing up some of Sedgwick's Lower Bala, and had drawn a continuous ascending section across it; that he had missed the true break at the base of the Silurian, and grouped

a great piece of the upper series with the lower unconformable beds? Alas! that was not done, he swept into his Silurian, all Sedgwick's Cambrian, down to the base of the Bala beds, and finding no break there, from time to time took in more of it till he left him at last only the lowest group, the Harlech, Llanberis, and Bangor beds.

Well, what next? Will it be believed that he now tried to throw the blame of his mistakes on Sedgwick; said, moreover, that it was his friends of the Survey, who applied the term Silurian to the slaty rocks of the western part of Wales?

It was no small injustice that wrung from the unselfish, noble Sedgwick such reproachful words, and that sent him to his grave with a sense of unrighted wrongs, of faithless friends and ungenerous enemies.

Is it good for the world that generosity and unselfishness shall be for ever unrecognised? Is it good for the student of science to feel that self-assertion is the chief requisite for success? The better nature of man rebels against such things. Many a one whose nature inclines him to share his last loaf with his hungry brother-man, may find the streams of charity dry within him, as he learns that he has been again and again cheated, and that when the world learned it was so, it coldly turned away.

But I would not end with this sad story.

Sedgwick's was a nature charged to the full with human sympathy. Bring joy near him, and he rejoiced; bring sorrow before him, and his pity overflowed in consolation; out of the fulness of his heart, his mouth spoke unmeasured unpremeditated words of gladness, or of sympathy. And though the friends of his youth passed away as shadows, he ever gathered round him the young and happy, and caught some of their life. Full of interest in all that was going on around him, the brave old man died in harness; and in 1873 was buried with the great men among whose memories he had so long lived. A simple A.S. marks the spot where his body was laid in the chapel of Trinity College, Cambridge.

GEOLOGICAL EXCURSION TO HOLDERNESS, THE KILNSEA SHELL MOUNDS, SPURN POINT, AND THE PILE DWELLINGS AT ULROME. BY JAMES W. DAVIS.

An excursion of the members of the society was made on July 21st to 23rd to Patrington, Easington, Kilnsea, and Spurn Point, and to Hornsea, Skipsea, and Ulrome, all in the district of Holderness. The party, on arriving at Patrington, were conveyed in carriages to the Neptune Inn, at Easington, where Mr. Lawton, the landlord, had tea in readiness. This part of the proceedings being completed, the carriages were re-entered, and the party drove to Kilnsea, a small village at the commencment of the narrow ridge of sand constituting Spurn Point. Two examples of the old refuse heaps or kitchen middens were visited, the first on the coast washed by the German Ocean, the second about 200 yards up the Humber, beyond the point where the road reaches the village. The early inhabitants appear to have selected or constructed a hollow in the glacial clays, about nine or ten feet broad, perhaps 60ft. in length, and four or five feet deep in the centre, with sloping sides. In this hollow they deposited the refuse from cooking, and other matters. The situation of the midden is usually indicated by a layer of oyster shells. The loamy soil above these is soft and comparatively loose, frequently a dark brownish black colour. It contains broken bones of the cow and sheep; and to a less extent of some other animals, of birds, &c., which served for food. Broken pottery of a coarse material and only partially burnt, thin Roman-like bricks and pieces of glass, and more rarely flint, bone, iron, and bronze implements are discovered. The whole is covered by a greater or less thickness of soil.

It unfortunately happened that the tide was at its highest point when the party first reached the middens. Considerable collections were however made, a bronze buckle and an iron instrument being the principal finds in addition to bones and pottery.

The amount of denudation on this part of the coast is very

great, though not always proceeding at the same rate. The average is probably 12ft. to 14ft. per annum; but during a severe storm in March last, as much as 50ft. in breadth was removed along a considerable line of coast. In other places, on the contrary, the foreshore becomes rapidly extended, as for instance at Patrington, where what is termed the Sunk Island, comprising 7,000 to 10,000 acres, has been reclaimed from the Humber, and is now cultivated; and whereas Patrington was formerly a seaport town, it is now far inland. Kilnsea church was washed away about sixty or seventy years ago, and its position is now 240 yards from the shore. Huge blocks of masonry, concreted together, rise considerably above the sands on the old site of the church. From Kilnsea towards Spurn Point the land rapidly converges southwards, and in about a mile has become so narrow between the North Sea on the one hand, and the Humber on the other, that any one might shoot an arrow across. The blown sand is piled up seawards to a height of about 12ft., but in the opposite direction it thins out to the level of the water. Further on the sandy cliffs become considerably higher, but proportionately narrow; they form in section a cone-shaped mound perhaps 20 yards wide, five or six yards across the top, and rise from the level of the sands to a height of 20 to 25ft. These sand dunes form a very fragile barrier to the stormy waters of the German Ocean, and the Board of Trade are at present engaged in supporting the bank seawards, by driving into the sand or glacial clay a long series of wood piles and groins. The necessity for this is proved by the fact that a short distance nearer the point, the sea broke through the barrier, and for some time resisted all efforts to stop it. Eventually, a wall was built of chalk brought from Hessle, and the continuity of the land was made and has since been maintained. At the extremity of the point its area widens considerably, and a short distance from the end is placed the lighthouse. Near the structure at present used, is a second one, which is now approached by a bridge, and is quite separated from the land at high water. The weather, showery during the early part of the day, cleared up, and a good view of the long line of the Lincolnshire coast was visible. Numerous vessels constantly entering and leaving the Humber made

a very pretty sight. The sandy soil of the headland affords nourishment to several species of plants and long grass. The latter was interspersed with lovely patches of pink and yellow flowers; rare and beautiful butterflies hovered about; and the tern or sea swallow gliding, fish in mouth, towards its offspring nestled in the sand, presented an extremely interesting picture.

On Monday morning the party proceeded to Hornsea, a summer resort for the people of Hull. It is situated on the coast, and the country in its neighbourhood is constituted of the stiff glacial clays and gravels characteristic of the whole of Holderness from the chalk of Bridlington to the Humber. The country is slightly undulating; little rounded hills of gravel rising from an otherwise unbroken level of small valleys. The lower parts of the country were, until comparatively recent times, covered by inland lakes, connected with one another, and ramifying in every direction. The construction of large drains and the general drainage of the surface has run off the water, and where was formerly a series of lakes and bogs, there is now a rich soil producing abundant harvests. An example of the old fresh-water lake still remains in Hornsea Mere, about half-a-mile from the shore, and from the point of view indicated it is peculiarly interesting. It is about a mile in length, and its deeper parts are below the level of the sea. Having inspected the lake, the members were driven to Skipsea, a distance of five miles, where they were met by Mr. Thomas Boynton, of Ulrome Grange, and the guidance of the party for the remainder of the day was relegated to his hands.

Proceeding to the shore at Whithowe, Mr. Boynton pointed out the site of one of the ancient lakes already mentioned. It originally extended far out to sea, and was of such extent and importance that Edward I., the lord of the manor, granted a tithe of fish to Robert de Chester in 1288. At present it is exposed in the cliff section, occupying a hollow in the surrounding glacial till or clay. Its principal characteristic consists in the thick beds of peat, which occupy and fill up the hollow. The peat has been formed by the gradual accumulation of vegetable matter at the bottom of the lake, and in some instances is nearly pure carbonaceous matter, proving that the influx of water bearing earthly matter in suspension was a circumstance of

comparatively rare occurrence. Proceeding from the coast past the church, which possesses a beautiful little porch erected in the reign of Queen Anne, the stronghold at Skipsea Howe was visited. These are very extensive and perfect, and, without doubt, afforded means of defence and protection to its inhabitants and those of the surrounding district. An interesting description of the site and its historical associations was given by the director; but as the members were more concerned in geological than archæological research, we pass them over, merely remarking that the original earthworks seem to have been erected by the ancient Britons far back in remote antiquity, and that their works have been greatly enlarged and strengthened by succeeding tribes or peoples.

Mr. Boynton next conducted the members along the side of the Skipsea and Barmston Drain to Ulrome, where the Rev. E. M. Cole, the author of a popular treatise on the geology of the East Riding, recently issued, and others from the neighbourhood of Driffield and Malton, joined the party. It is at Ulrome that the pile dwelling, discovered and excavated by Mr. Boynton, is situated. Whilst deepening the drain three years ago, a number of bone tools and rotten timbers were discovered, which had evidently been worked and used by some former inhabitants of the country. They were, in some instances, sharpened at one end in a rough and rude manner, and appeared to have been used as piles. Mr. Boynton's curiosity was excited, and he commenced an excavation on the east bank of the drain in the first instance, and afterwards on the opposite side, A rectangular surface is now exposed about 20 yards by 30, and the whole of this is covered by trunks of trees laid horizontally, and fastened and held in position by pointed piles driven into the ground on each side or at the ends. The general construction, as explained by Mr. Boynton, is as follows:—The structure was erected on the edge of a lake, with rising ground eastwards and westwards. The bed of the lake was composed of sandy gravel, above which about 2ft. of peat had been deposited. On this the builders placed the tree trunks, crossing each other horizontally, and for the most part without any definite arrangement. The largest trunks measure about 18in. in diameter and perhaps 20ft. in length, except in rare

instances they have not been hewn into shape, but laid in the bed of the lake in the condition in which they were felled after the branches had been removed. The largest trunks are placed from east to west across the course of the stream, which connected more expanded and lake-like areas to the northwards and southwards. Transversely with the timbers from east to west, others were laid and fastened in position so as to form a tolerably compact and solid framework. They were fastened in position by rudely pointed stakes driven, generally, with a diagonal inclination, into the bottom of the lake. At the north-east corner of the platform thus formed, a pair of parallel timbers of large size, about 5ft. apart, and more carefully hewn and fixed than most of the others, appear to indicate that the entrance, or connection between the dwelling and the adjoining land, was placed in this position. The trunks and branches consist for the most part of oak, ash, birch, hazel, and willow. Hazel-nuts are frequently met with.

The interstices between the timbers of the platform were filled with broken wood and twigs until a level surface was obtained. On the solid surface thus obtained, there was placed an additional thickness of about 18in. of broken twigs and bark, and on this foundation, probably reaching a short height above the surface of the water, were erected the dwellings of the builders. Since the demolition of the buildings or dwellings there has accumulated about 3ft. of peat and peaty marl, and above this, forming the surface, there is more than a foot of warp and soil; so that the whole is about 10ft. in depth from the surface of the ground to the bed of gravel at the base. It is probable that after the first platform had served for the support of dwelling erected upon it, that it became necessary to raise it; for it is found that a second one has been placed above it. The stakes used in fastening the timbers of the second, are frequently found driven into the timbers of the preceding one, so that the older structure must have been laid a considerable time, and the timbers have become more or less decayed, or this could not have happened. The stakes of the latter dwelling have a longer and better made point than the older ones, and appear to have been cut by superior tools.

During the excavation many interesting relics of the occupiers

of the dwellings have been found, mostly consisting of stone and bone implements. Amongst the former are several rounded stones, used for pounding grain or other matters; pointed or sharpened stones pierced in the middle for the introduction of a handle, and used as hammers; a large stone of oval form, coarse texture, with flat surface, exceeding a foot in diameter may have been used in grinding food. Flint flakes used as knives and for other purposes have been found. The bone implements are mostly of large size and rude form. The large leg bones of the cow (Bos longifrons), probably the humerus, broken off diagonally about 8in. from the joint, and a hole bored immediately below the joint, for the insertion of a stick, formed an implement that would serve very well the purpose of a hoe for breaking up the land. The antlers of the red deer appear to have been used by these people as in other similar places, for digging purposes, and are frequently met with. Numerous nuts are found; pieces of pottery, of an early British type occur. In addition to the bones of the animals named, there have been found the jaws of wolves, tusks of wild boar, head of horse and of red deer; bones of sheep, dog, and of smaller animals, as well as the bones of birds. All these have been found beneath the upper structure, amongst the twigs and bark in the interstices between the timbers of the lower and earlier one, at a depth about 6ft. from the surface, and about 4ft. above the bottom of the lake.

In the upper part of the dwelling a fine bronze spear head was found. The discovery of this implement has led to the inference that the later dwelling was erected during the period usually denominated the Bronze Age; whilst in all probability the older foundations were laid at a much earlier time represented by the early Stone Age. It will be interesting to note the discoveries during future excavations, to ascertain whether other dwellings exhibit a similar duplicate arrangement, and afford evidence that peoples of so different intelligence and civilization, as those living in the Neolithic and Bronze Ages, occupied dwellings so nearly approximating in structure, as appears to have been the case in the present instance.

Judging from the remains which have hitherto been discovered, it appears probable that the people who erected the dwellings on

the borders of the lake did so for protection against the wild animals which existed in the country at that time and for long afterwards, rather than for defence against human foes. That they followed agricultural pursuits is proved by the bone implements, which are admirably adapted for working in the light warpy soil on the higher ground bordering the lake. Mr. Boynton suggests that the lake dwellers, if alarmed, could easily retire to Skipsea, which was probably an intrenched and fortified place at the time the dwellings were erected, and that, under ordinary circumstances, they were peaceable and industrious agriculturists.

Having carefully examined the site and structure, so far as it remains, of the old dwelling, those present were conducted by Mr. Boynton to his residence, Ulrome Grange, where he entertained the company to dinner. At its conclusion the Hon. Secretary expressed the indebtedness of the society to their host, and also stated that the thanks of the scientific world were due to Mr. Boynton for the energy and skill he had displayed, and the expense he had incurred in excavating so large an area of the old pile dwellings. This was the first recorded instance of a similar structure having been found in England. Dwellings of a similar character have been found and investigated in Scotland and Ireland with great scientific advantage, and he (Mr. Davis) hoped, and had no doubt, that Mr. Boynton would be amply repaid for the trouble he had taken, by the extension of the knowledge of the people and their habits, whose otherwise unrecorded history he was so ably assisting to elucidate. Mr. Boynton replied that the visit of the society had afforded him considerable pleasure, and he wished to state his opinion that the dwelling which had been examined was not an isolated instance, but that in all probability the country was studded with them. He already knew the sites of five such dwellings, or clusters of dwellings, for he did not think that they were inhabited by single families only. Each of those would no doubt well repay examination, so that the knowledge of them might yet be very much extended.

After an examination of Mr. Boynton's rich collection of objects obtained from the excavations, the party left to return to their several destinations, having spent an extremely pleasant and instructive holiday in Holderness.

SECRETARY'S REPORT.

THE present meeting is the fourth held during the year. The members have met on three occasions at which papers have been communicated; the fourth took the form of an excursion in Holderness. The first meeting was held at Leeds, in the Lecture Theatre of the Philosophical and Literary Society, on February 14th; Wm. Cheetham, Esq., presided, and papers were contributed by Messrs. G. R. Vine, W. H. Hudleston, President of the Geologists Association, London; and Arnold Lupton, Memb. I.C.E., Mining Instructor at the Yorkshire College. The second meeting was held at the Town Hall, Ripon, on May 9th, and the chair was occupied by Rev. W. C. Lukis, M.A., F.S.A., who gave an address; papers were contributed by Mr. H. B. Hewetson, and Rev. J. Stanley Tute, B.A.

On July 21st and 23rd, an excursion to Patrington, Kilnsea, and Spurn Point took place. The members met at Hull, and went by rail to Patrington, after inspecting the beautiful old church, they were driven to Easington, and thence to Kilnsea: at the latter place a number of ancient "Kitchen middens" were examined. On the following day some of the party walked to the end of Spurn Point. The members left Easington on the 23rd, and proceeding by way of Hull, went to Hornsea, and after inspecting Hornsea Mere, a large lake below the level of the sea, drove to Skipsea, where Thos. Boynton, Esq., of Ulrome Grange, met the party. Proceeding first to the coast, a section of an ancient lake exposed in the cliff, was inspected. From thence, by way of Skipsea Howe, the party walked along the side of the Barmston drain to a lake-dwelling at Ulrome, which Mr. Boynton discovered, and has since excavated.

Full and detailed particulars of the excursion, and more especially the Lake Dwelling, will be found in a separate paper to be printed in the proceedings of the society. After inspecting the Lake Dwelling, the members were conducted by Mr. Boynton to his residence, where he entertained them at dinner, and afterwards exhibited his collection of implements and pottery found during the excavations of

the dwellings, as well as a magnificent series of flint weapons found on the surface of the surrounding country.

The annual meeting was held at Halifax, in the Lecture Theatre of the Literary and Philosophical Society, on November 28th. The President of the Institution, Lieut.-Col. Louis J. Crossley, J.P., F.R.M.S., &c., occupied the chair, and afterwards entertained the members present at dinner. Papers were read by Prof. T. Mc. K. Hughes, M.A., &c., Professor of Geology, at Cambridge; Messrs. Richard Carter, C.E., W. Cash, F.G.S., Geo. R. Vine, W. V. Veitch, M.D., Geo. W. Lamplugh, and T. H. Easterfield.

The thanks of the society are due to the councils of the Leeds and Halifax Philosophical Societies, and to the City Council at Ripon, for the use of their rooms; to the gentlemen who have presided at the meetings; and to Mr. Boynton, for the generous help and guidance, readily accorded during the visit of the society to Holderness.

The present number of members is 212, of whom 25 have compounded for their annual subscription by a payment of six guineas, and 187 are ordinary members; 17 new members have been added during the year. The death of R. W. Morrel, of Bradford, has deprived the society of a useful member, and in addition, seven others have withdrawn from the society, leaving a nett gain of nine members during the year.

The thanks of the society are due to the Local Secretaries for their continued interest in the society, and for the painstaking manner in which they have on all occasions attended to the duties of their office. The following is a list of the Local Secretaries and the towns or districts under their supervision :—

Barnsley	Thomas Lister.
Bradford	Thos. Tate, F.G S.
Bridlington	Geo. W. Lamplugh.
Brighouse	T. W. Helliwell.
Driffield and District	Rev. E. Maule Cole, M.A., F.G.S., &c.
Halifax...	George Patchett, junr.
Huddersfield	Peace Sykes.
Hull	G. J. Wilson, M.A., &c.
Leeds	J. E. Bedford.

Mexbro' ... ... Rowland Gascoigne, F.G.S.
Middlesbrough ... . W. Y. Veitch, M.D.
Selby ... ... J. T. Atkinson, F.G.S.
Sowerby Bridge ... . J. Marshall, F.G S.
Thirsk ... ... W. Gregson.
Wensleydale .. .. W. Horne.

The following is a list of those societies to which the proceedings of this society are forwarded, and which in return present us theirs :—

Essex Naturalists Field Club.
Norwich Geological Society.
Yorkshire Archæological and Topographical Society.
Warwickshire Natural History and Archæological Society.
Royal Society of Tasmania.
Royal Dublin Society.
Royal Historical and Archæological Association of Ireland.
Geologists' Association, London.
Manchester Geological Society.
Literary and Philosophical Society, Liverpool.
Royal Institution of Cornwall.
Royal Geological Society of Ireland.
United States Geological Survey of the Territories.
Boston Society of Natural History.
Hull Literary and Philosophical Society.
Connecticut Academy of Arts and Sciences.
Academy of Science, St. Louis.
Historical Society of Lancashire and Cheshire.
Geological Society of London.
Royal University of Norway.
Société-Geologique du Nord.
Royal Society of Edinburgh.
Royal Geological Society of Cornwall.
Royal Physical Society of Edinburgh.
Oversigt over det Kongelige Danske Videnskabernes Selskabs, Kjopenhavn.
Museum of Comparative Zoology, Cambridge, U.S.A.
Watford Natural History Society and Herefordshire Field Club.

Copies of the Proceedings of the Society for the following years may be had on application to the Honorary Secretary, Chevinedge, Halifax, price 2s. 6d. each :—
1840, 1841, 1842, 1843, 1844-5, 1845-6, 1847, 1848, 1851, 1853,

1854-5, 1858-9, 1860, 1862, 1864-5, 1865-6, 1867, 1868, 1869, 1870, 1871, 1875, 1876, 1877, 1878, 1879, 1880, 1881, 1882.

During the past year the quarrying operation in the immediate vicinity of the Rayhill Fissure have been of such a nature as to prevent the progress of the work of the Committee appointed to superintend its exploration. There is every probability that, with the approach of next spring, the whole of the intervening limestone will have been cleared away, and that active operations may be again commenced in the Fissure.

The society acknowledges, with much pleasure, its indebtedness to Mr. W. H. Dalton, of H. M. Geological Survey, for his kindly rendered assistance in the compilation of the Bibliographical lists of works published during the past year, and which are appended.

Statement of Receipts and Expenditure of the West-Riding Geological and Polytechnic Society,

From OCTOBER, 1882 to OCTOBER, 1883.

Dr.	£	s.	d.	Cr.	£	s.	d.
To Balance	10	0	0	By Cash paid into the Bank	62	9	9
„ Subscriptions	62	9	9	„ Cost of Photographs and Stationery ...	68	0	10
„ Beckett & Co.	68	0	10	„ Balance in hand	10	0	0
	£140	10	7		£140	10	7

THE TREASURER IN ACCOUNT WITH MESSRS. BECKETT & CO.

To Balance at Bank	38	11	9	By Cash from Bank	68	0	10
„ Cash paid to Bank	62	9	9	„ Balance at Bank	33	15	9
„ Interest	0	15	1				
	£101	16	7		£101	16	7

CAPITAL ACCOUNT.

To Balance at Bank	148	18	0	By Balance at Bank	165	2	8
„ Subscriptions	12	12	0				
„ Interest	3	12	8				
	£165	2	8		£165	2	8

RAYGILL QUARRY EXPLORATION FUND ACCOUNT.

To Balance at Bank	29	4	0	By Balance at Bank	29	16	1
„ Interest	0	12	1				
	£29	16	1		£29	16	1

Examined and found correct, G. PATCHETT, Junr.

MINUTES.

Meeting of the Council, Dec. 13th, 1882, at the Museum, Leeds. Present, R. Carter, Esq., in the chair, Messrs. Cheetham, Bedford, Tate, Sladen, Atkinson, Rowley, and Hon. Secretary.

The Minutes of last meeting were read and confirmed.

Proposed by Mr. Atkinson, seconded by Mr. Cheetham, "That the following amounts be paid."

E. Wormald	£1	12	0
"Pontefract Express"	0	7	6

Proposed by Mr. Sladen, seconded by Mr. Tate, and carried, "That the recommendation of the revision Committee that a series of Biographical Memoirs of eminent Yorkshire Geologists be printed in the proceedings, be adopted; and that the Memoir of John Phillips, by Mr. J. W. Davis be accepted for this year's proceedings."

Proposed by Mr. Cheetham, seconded by Mr. Tate, and carried, "That the next Meeting of the society be held at Leeds, in February, and that Messrs. Vine and Hudleston, and others, if available, read papers.

General Meeting held in the Lecture Theatre, Museum, Leeds, Feby. 14th, 1883, Wm. Cheetham, Esq. occupied the chair.

The Minutes of last General Meeting were read and confirmed.

Proposed by Mr. McLandesborough, seconded by Mr. Davis, and carried, "That Mr. A. E. Preston, C.E., F.G.S., The Exchange, Bradford, be a member of the Society."

Papers were read by W. H. Hudleston, F.G.S., &c., "On the Physical Geology and Geography of Palestine and the adjacent countries."

Arnold Lupton, C.E., F.G.S., "On the Channel Tunnel; notes of a visit."

George R. Vine, "Notes on the Carboniferous Polyzoa of West Yorkshire and Derbyshire (an attempt to identify Professor Phillips' species)."

Proposed by Mr. Davis, seconded by Mr. Rowley, "That the next Meeting of the society be held at Ripon," carried.

Proposed by Mr. Tate, seconded by Mr. Lee, and carried, "That the thanks of the meeting be given to the Chairman and authors of papers."

Meeting of the Council, Town Hall, Ripon, May 9th, 1883. Present, Rev. W. C. Lukis, F.S.A. in the chair, Messrs. Gregson, Cole, and Davis.

The Minutes of the last meeting were read and confirmed.

The following accounts were passed and ordered to be paid.

	£	s.	d.
A. Megson & Sons -	53	15	6
E. Wormald - -	1	14	0
Hy. Sykes - -	1	1	0
Autotype Co. - -	11	10	4
"Pontefract Express"	0	7	6
,, Telegraph	0	7	9
,, Advertiser	0	8	0

It was resolved that there be an excursion of the members on the Yorkshire Coast, the district between Scarbro' and Filey being suggested if suitable arrangements can be made, in the early part of August. Resolved that the photograph for next year be a section on the coast, near Scarborough.

General Meeting at the Town Hall, Ripon, on May 9th, 1883. The Rev. W. C. Lukis, M.A., F.S.A., Rector of Wath, occupied the chair. The Minutes of last General Meeting were read and confirmed.

The following gentlemen were elected members of the Society :—

Sir Charles Dodsworth, Bart., Thornton Watlass, Bedale.
Jas. Carter, Burton House, Thirsk.
T. Carter Mitchell, Topcliffe, Thirsk.
J. Dyson Butler, Estate Buildings, Huddersfield.
Jno. Hanstock, Denby Grange, near Wakefield.
Mrs. Tetley, Foxhills, Weetwood, Leeds.
Thos. Dalton, Albion Street, Leeds.
Percy Lund, Ilkley.
Robt. Peach, Harrogate.
Wilfrid H. Hudleston, M.A., F.G.S., Culverden Lodge, Oatlands Park, Weybridge.

The Chairman stated that the next meeting of the society would be held as an excursion on the Yorkshire coast, in August, and the annual meeting at Halifax.

The Chairman gave an address.

The following papers were read :—

H. B. Hewetson, "On the shell mounds or kitchen middens at Spurn Point"

Rev. J. Stanley Tute, B.A., "On the sequence of the Permian Rocks, near Ripon.

Rev. J. S. Tute, B.A., "On a raised beach at Redcar."

T. C. Mitchell read a communication "On a peculiar celt or flint which had been obtained from a French millstone."

Proposed by the Rev. E. M. Cole, seconded by Mr. Cheetham, that thanks be given to the Chairman, and authors of papers.

Meeting of the Council,—At the Museum, Halifax, Nov. 28th, 1883. Present, Wm. Alexander, M.D., J.P., in the chair; Messrs. Cheetham, Rowley, Cash, Sykes, Crossley.

The Minutes were read and confirmed.

Proposed by Mr. Cheetham, seconded by Mr. Sykes, that the following accounts be paid.

	£	s.	d.
E. Wormald - -	0	7	3
S. S. Hill - - -	0	4	0
G. Willis - - -	2	6	0

Annual General Meeting in the Lecture Theatre, Literary and Philosophical, Halifax, Nov. 28th, 1883.

The chair was occupied by Lieut.-Col. Louis J. Crossley, J.P., F.R.M.S., &c.

The Minutes of the last general meeting were read and confirmed.

The Honorary Secretary read an annual report and balance sheet, which was adopted on the motion of the Chairman, seconded by Mr. Rowley.

The following gentlemen were elected members of the society :—

H. B. Hewetson, 11, Hanover Place, Leeds.
T. C. Heslington, North Road, Ripon.
— Scargill, East Parade, Sheffield.
Ed. Hailstone, F.S.A., Walton Hall, Wakefield.
R. T. G. Abbott, Auburn Hill, Malton.
Joseph Davidson, F.C.S., Holywell Green, Halifax.
T. C. Scratcherd, Halifax.
Francis Fleming, Halifax.
George Patchett, jun., Halifax.
W. Gaukroger, Halifax.
L. J. Crossley, J.P., &c., Moorside, Halifax.
Geo. R. Vine, 112, Hill Top, Attercliffe, Sheffield.

A letter was read from John Brigg, Esq., tendering his resignation of the office of Treasurer.

It was proposed by Mr. Cheetham, seconded by Mr. Parke, and carried, "That the thanks of the society be given to Jno. Brigg, Esq., J.P., for his valuable services as Treasurer during the past eight years; and to the officers for their services during the past year."

Proposed by Dr. Alexander, seconded by Mr. Rowley, and carried, "That the Marquis of Ripon be re-elected President for the ensuing year."

Proposed by Mr. Rowley, seconded by Mr. Bedford, and carried, "That the following noblemen and gentlemen be elected Vice-presidents for the next year:—Earl Fitzwilliam, Duke of Leeds, Earl of Effingham, Earl of Dartmouth, Earl of Wharncliffe, Viscount Galway, Lord Houghton, Viscount Halifax, H. C. Sorby, Esq., LL.D., T. W. Tew, Esq., J.P., Walter Morrison, Esq., J.P., W. T. W. S. Stanhope, Esq., J.P., Lieut.-Col. L. J. Crossley, J.P., and Thos. Shaw, M.P., &c.

Proposed by Mr. Davis, seconded by Mr. Stott, and carried, "That W. Cash, Esq., F.G.S., &c., be elected Treasurer."

Proposed by Mr. Crossley, seconded by Mr. Gaukroger, and carried, "That Jas. W. Davis be the Honorary Secretary for the ensuing year."

Proposed by Mr. Peach, seconded by Mr Gray, and carried, "That the following gentlemen form the council for the ensuing year:—

Wm. Alexander, M.D.	R. Carter, C.E., &c.
W. Cheetham.	J. R. Eddy, F.G.S.
T. W. Embleton, C.E.	E. Filliter, C.E.
Prof. A. H. Green, M.A.	Prof. L. C. Miall.
R. Reynolds, F.C.S.	W. Rowley, F.G.S.
W. S. Ward, Esq., F.C.S.	G. H. Parke, F.G.S.

The Chairman gave a brief address, and the following Papers were read:—

Professor Thos. M'Kenny Hughes, M.A., &c., "Biographical Sketch of Prof. Adam Sedgwick."

Richard Carter, Esq., C.E., F.G.S., on "A Meteorite which fell at Harrogate, in June, 1883."

Wm. Cash, Esq., F.G.S., on "The young stage of some Carboniferous Cephalopoda."

Geo. R. Vine, Esq., on "The Entomostracoda of the Richmond and North Yorkshire Carboniferous Shales."

W. Y. Veitch, Esq., M.D., on "The evidences of raised Beaches on the Yorkshire Coast."

Geo. W. Lamplugh, Esq., on "The Drainage Sections at Bridlington.—The Fresh-Water Gravels."

T. H. Easterfield, Esq., on "A Glacial Deposit near Doncaster."

Mr. Cheetham proposed, and Mr. Parke, Seconded, a vote of thanks to the Chairman, and authors of Papers, carried.

The members of the society, at the invitation of Mr. Crossley, adjourned to the Masonic Hall, where he entertained them at dinner.

Summary of Geological Literature relating to Yorkshire, Published during 1883, with Addenda for 1879-1882.

Compiled by James W. Davis.

1879.—ADDENDA.

Cameron, A. G. Lecture on Geology. *Cleveland News*, Feb. 15.

Clark, J. E. Askham Bog. *Nat. Hist. Journ.*, vol. iii., pp. 113-115, pl. viii.

Crosskey, Rev. H. W. Seventh Report of the Committee for recording Erratic Blocks. *Rep. Brit. Assoc.* for 1879, pp. 135-140.

Dakyns, J. R. Lenticular Hills of Glacial Drift. *Geol. Mag.* dec. ii., vol. vi., pp. 382-383.

——— The Purple Boulder Clay at Holderness. *Ibid*, p. 528.

De Rance, C. E. Fourth Report of the Committee . . . . on the Underground Waters . . . . of England. *Rep. Brit. Assoc.* for 1878, pp. 382-419. (Yorkshire, pp. 412-416.)

——— Notes on some Triassic Borings. *Trans. Manch. Geol. Soc.*, vol. xv., pt. v., pp. 90-112. (Middlesboro'.)

Etheridge, R., junr. Notes on the Bivalves contained in the Gilbertson Collection, British Museum and figured in Phillips' "Geology of Yorkshire." *Geol. Mag.*, dec. ii., vol. vi., pp. 161-166.

Gunn, W. Glaciation of the West Yorkshire Dales. *Geol. Mag.*, dec. ii., vol vi., p. 384.

Jones, Professor T. R. and J. W. Kirkby. Description of the Species of the Ostracodous Genus Bairdia, M'Coy, from the Carboniferous Strata of Great Britain. *Quart. Jour. Geol. Soc.*, vol. xxxv., pp. 565-581, pls. xxviii.-xxxii.

Tiddeman, R. H. Sixth Report on the Exploration of the Settle Caves (Victoria Cave). *Rep. Brit. Assoc.* for 1878, pp. 377-380.

Guide to the Town and District of Sheffield, specially prepared for the Members and Associates attending the Sheffield Meeting of the British Association. (By A. H. Green, J. M. Mello, G. R. Vine, and others.) Edited by J. Taylor, pp. viii, 160. 8vo. Sheffield.

1880.

De Rance, C. E. Sixth Report of the Committee . . . . on the Underground Waters . . . . of England . . . *Rep. Brit. Assoc.* for 1880, pp. 87-106.

Jukes-Browne, A. J. The Sub-divisions of the Chalk. *Geol. Mag.*, dec. ii., vol. vii., p. 248.

1881.

Hudleston, W. H. Contributions to the Palæontology of the Yorkshire Oolites. Parts vi., vii. *Geol. Mag.*, dec. ii., vol. viii., pp. 49-59, 119-131, pls. iii, iv.

Phillips, J. A. On the Constitution and History of Grits and Sandstones. *Quart. Jour. Geol. Soc.*, vol. xxxvii., pp. 6-28, pls. i., ii.

1882.

Meade, R. The Coal and Iron Industries of the United Kingdom, pp. xxi., 876. 2 Maps, 8vo., *London.*

1883.

CASH, W. Yorkshire Fossil Mollusca. *Proc. Yorks. Geol. and Polyt. Soc.*, vol. viii, pp. 77-88.

COLE, Rev. E. M. On the White Chalk of Yorkshire. *Proc. Yorks. Geol. and Polyt. Soc.*, vol. viii., pp. 21-27.

DAKYNS, J. R. The Bridlington Crag. *Geol. Mag.*, dec. ii., vol. x., p. 93.

DAVIS, J. W. On the Fossil Fishes of the Carboniferous Limestone Series of Great Britain. *Trans. R. Dublin Soc.*, ser. 2, vol. i., pp. 327-600, pls. xlii.-lxv.

——— Biographical Notices of Eminent Yorkshire Geologists. I. "John Phillips." *Proc. Yorks. Geol. and Polyt. Soc.*, vol. viii., pp. 3-20.

——— Notes on the Occurrence of Fossil Fish Remains in the Carboniferous Limestone Series of Yorkshire. *Ibid*, pp. 39-63.

——— On Some Sections Exposed during the formation of the line of railway between Upton and Kirk Smeaton. *Ibid*, pp. 107-113.

——— Summary of Geological Literature relating to Yorkshire, published during 1882, with Addenda for 1881. *Ibid*, pp. 147-148.

EDDY, J. R. On the Lead Veins in the neighbourhood of Skipton. *Proc. Yorks. Geol. and Polyt. Soc.*, vol. viii., pp. 63-69.

HUDLESTON, W. H. Notes on the Excursion to the West Riding of Yorkshire. *Proc. Yorks. Geol. and Polyt. Soc.*, vol. viii., pp 113-135.

KEEPING, W. The Geology of the New Railway Cuttings in the Cave District, South Yorkshire. *Ann. Rep. Yorks. Phil. Soc.* for 1882, p. 45.

——— and C. S. MIDDLEMISS. On Some New Railway Sections and other Rock Exposures in the district of Cave, Yorkshire. *Geol. Mag.* dec. ii., vol. x., pp. 215-221.

LAMPLUGH, G. W. Glacial Sections near Bridlington. Part ii. *Proc. Yorks. Geol. and Polyt. Soc.*, vol. viii. pp. 27-38.

——— Thornwick Bay, Flamborough. *Ibid*, pp. 103-107.

LAW, R. and JAMES HORSFALL. On the Discovery of Flint Implements on the hills between Todmorden and Marsden. *Proc. Yorks. Geol. and Polyt. Soc.*, vol. viii., pp. 70-76.

MACKINTOSH, D. Results of Observations in 1882, on the Positions of Boulders relatively to the Underlying and Surrounding Ground, in North Wales and North-west Yorkshire; with remarks on the evidence they furnish of the recency of the close of the Glacial Period. *Quart. Jour. Geol. Soc.*, vol. xxxix., *Proc.* pp. 67-69.

READE, T. M. The Drift-beds of the North-west of England and North Wales. Part ii.—Their Nature, Stratigraphy and Distribution. *Quart. Jour. Geol. Soc.*, vol. xxxix., pp. 83-132, pl. v.

TEW, T. W. On the Recent Extension of Mining Operations under the Permian Formation. *Proc. Yorks. Geol. and Polyt. Soc.* vol. viii., pp. 89-102.

WOODWARD, Dr. H. Synopsis of the Genera and Species of Carboniferous Limestone Trilobites. *Geol. Mag.*, dec. ii., vol. x, pp. 445 454 and 481-487, pls. xi., xii.

*** The Society is much indebted to the kindness of Mr. W. H. Dalton, of H.M. Geological Survey, for his assistance in the above compilation.

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*** It is requested that Members changing their residence will communicate with the Secretary.

.m.	NW.	Mean Amount of Cloud.	Rain. Number of Days it fell.	Amount Collected.	Greatest Daily Fall.	Date.	Mean of Fifteen Years.	Mean of Seven Years ending with 1882, 65½ft. above surface of ground.	Mean of 7 Yrs. endg. with 1882 at T'n Hall and Mid. Ry. Station on surface of ground.	Gr'ter fall on surface at Town Hall & Mid. Stn. than at 65½ft. above surface at Exch.	
										Depth in Inches.	Percentage of fall at Exch'ge
	No.	0—10	No.	Ins.	Ins.	On	Ins.	Ins.	Ins.	Ins.	Per cent
	7	7·5	22	5·00	0·86	28th	2·61	2·209	2·474	0·265	11·2
	5	7·0	16	1·52	0·26	7th	2·00	2·609	2·972	0·363	11·4
	12	6·3	13	0·89	0·34	7th	2·15	2·776	3·260	0·494	11·7
	5	6·5	9	2·64	0·95	28th	2·15	2·516	2·835	0·319	11·2
	7	5·8	13	0·58	0·13	11th	1·81	2·103	2·277	0·174	10·8
	2	6·9	21	3·51	0·86	29th	2·57	2·837	3·011	0·174	10·6
	4	6·2	20	3·86	1·07	21st	2·85	3·401	3·641	0·240	10·7
	4	6·0	16	2·09	0·99	3rd	2·84	3·654	3·892	0·238	10·7
	6	7·3	22	6·23	1·34	26th	3·12	2·894	3·229	0·335	11·2
	9	7·2	18	3·65	0·71	17th	3·58	3·640	4·012	0·372	11·0
	8	7·1	22	3·11	0·49	5th	2·96	3·421	3·828	0·407	11·2
	10	7·3	14	1·32	0·28	11th	2·82	3·681	4·170	0·489	11·3
	79	6·8	206	34·40	0·69		31·48	35·741	39 601	3·860	11·08

on the top of central roof of the Exchange, at an elevation of 65½ feet
nd and 395 feet above mean sea level. As rain gauges on the summit
und to collect less rain than when placed upon the surface of open
ps were taken in 1875 to determine to what extent this was the case
ge, when two additional gauges were provided and fixed upon the
es, one near to the Town Hall, the other near to the Midland Railway
Exchange gauge is situate about midway, and the surface of ground
both of these gauges, as well as at the Exchange gauge, daily
the commencement of 1876 to the end of 1882, a period of seven years,
re removed in consequence of the ground they occupied being no
ose. The particulars of these gaugings are set forth in tables. The
yearly rainfall on the surface of ground for the seven years ending
·08 per cent., greater than at the summit of the Exchange. The mean
ie Exchange for the fifteen years ending with 1883 is 31·477 inches.
reto the mean normal rainfall of central Bradford for such period is
r annum. There are good grounds for concluding that the smaller
on the Exchange—and on buildings generally—than on the surface
ring direction and force of wind there producing different currents
due precipitation on the top or ridge of roof where the gauge is

which the observations are made have been verified by comparison
bservatory.

METEOROLOGY OF BRADFORD FOR 1883.

Computed from daily observations made at the Exchange, Bradford.

By John McLandsborough, F.R.A.S., F.R. Met. Soc., F.G.S., and Alfred Eley Preston, Assoc. M. Inst. C.E., F.R. Met. Soc., F.G.S.

Latitude, 53 deg. 47 min. 38 sec. N.; longitude, 1 deg. 45 min. 4 sec. W. Height above mean sea level, 366 ft.

Pressure of Atmosphere in Month.

Month.	Highest Reading of Barometer	Date.	Mean of Highest of 15 Years.	Lowest Reading of Barometer.	Date.	Mean of Lowest of 15 Years.	Range.	Corrected for Capillarity and Temperature: Mean.	Corrected: Mean of 15 Years.
	Ins.	On	Ins.	Ins.	On	Ins.	Ins.	Ins.	Ins.
January	30·212	28th	30·195	28·492	26th	28·737	1·720	29·395	29·524
February	30·360	23rd	30·073	28·528	2nd	28·742	1·832	29·557	29·487
March	30·352	3rd	30·138	28·828	30th	28·603	1·524	29·539	29·501
April	30·600	9th	30·105	29·016	16th	28·611	1·484	29·582	29·482
May	30·058	17th	30·069	29·228	10th	29·079	0·830	29·554	29·570
June	30·052	13th	29·999	29·296	26th	29·141	0·756	29·548	29·532
July	29·090	27th	29·869	29·062	12th	29·147	0·836	29·393	29·608
August	29·094	23rd	29·080	29·022	16th	29·655	0·972	29·514	29·497
September	29·094	13th	30·064	28·462	2nd	28·932	1·642	29·407	29·490
October	30·164	30th	30·120	28·254	16th	28·741	1·310	29·493	29·447
November	29·944	1st	30·019	28·600	25th	28·659	1·438	29·349	29·422
December	30·226	7th	30·100	28·068	14th	28·687	1·158	29·677	29·466
Means, or totals	30·140		30·073	28·863		28·678	1·283	29·501	29·491

Temperature of Air in Month.

Month.	Highest.	Date.	Mean of Highest of 15 Years.	Lowest.	Date.	Mean of Lowest of 15 Years.	Range.	Mean: Of all Highest.	Mean of 15 Years.	Of all Lowest.	Mean of 15 Years.	Daily Range: Mean.	Daily Range: Mean of 15 Years.	Of Dry Bulb: Mean.	Of Dry Bulb: Mean of 15 Years.
	Deg.	On	Deg.	Deg.	On	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.
January	54·1	2nd	52·7	26·6	31st	23·1	27·5	43·8	43·0	35·7	34·2	8·1	8·8	40·0	39·3
February	54·0	22nd	53·8	27·8	1st	27·1	28·2	46·2	44·6	38·0	35·7	8·2	6·0	42·4	40·2
March	54·4	6th	56·6	19·8	10th	26·1	34·6	41·6	47·0	20·9	35·6	11·7	11·4	35·1	40·8
April	63·8	10th	66·1	32·1	25th	31·7	31·7	53·7	53·6	39·2	40·0	14·5	13·5	46·0	45·3
May	71·6	17th	68·9	33·0	5th	34·6	38·6	58·8	58·5	43·7	43·7	15·1	14·8	50·1	49·6
June	75·0	30th	76·8	44·0	4th	41·9	31·0	64·3	65·2	49·0	50·1	14·4	16·1	55·2	55·8
July	76·2	3rd	80·4	45·8	15th	47·1	30·4	65·8	68·8	62·2	54·0	13·7	14·8	67·0	60·5
August	74·2	26th	78·7	49·0	23rd	[illegible]	26·2	67·4	67·7	53·2	53·3	14·2	14·4	68·3	59·2
September	68·7	19th	70·7	44·1	9th	40·5	24·6	61·7	62·2	50·7	49·8	11·0	12·6	55·1	54·5
October	62·4	9th	64·3	33·6	22nd	32·6	28·8	54·2	54·3	44·3	43·5	9·9	10·8	48·6	48·6
November	66·2	29th	56·2	29·2	12th	20·4	27·0	46·0	47·2	38·2	38·0	8·7	8·2	42·6	42·7
December	64·0	14th	63·2	28·0	7th	22·9	25·0	45·1	42·6	37·1	34·2	8·0	8·4	41·3	39·1
Means, or totals	63·7		64·8	34·5		33·5	29·2	[illegible]	54·6	42·7	42·7	11·4	11·9	47·7	48·0

Adopted Mean Temperature. — Vapour.

Month.	Of Air: Mean.	Of Air: Mean of 15 Years.	Of Evaporation: Mean.	Of Evaporation: Mean of 15 Years.	Dew Point: Mean.	Dew Point: Mean of 15 Years.	Elastic Force: Mean.	Elastic Force: Mean of 15 Years.	In a Cubic Foot of Air: Mean.	Mean of 15 Years.	Short of Saturation.	Mean of 15 Years.
	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Ins.	Ins.	Grs.	Grs.	Grs.	Grs.
January	39·8	38·8	38·3	37·1	36·3	34·7	·215	·204	2·6	2·4	0·4	0·4
February	42·0	40·0	40·0	38·3	37·6	36·0	·225	·213	2·6	2·5	0·5	0·4
March	34·9	40·5	33·4	38·2	31·0	35·3	·173	·207	2·0	2·4	0·4	0·5
April	45·6	45·4	41·5	42·0	36·9	38·1	·221	·233	2·8	2·7	0·5	0·8
May	49·8	49·5	45·2	45·1	40·3	41·0	·251	·258	2·9	3·0	1·2	1·1
June	55·2	55·7	50·5	51·3	46·0	46·9	·312	·322	3·5	3·6	1·4	1·3
July	57·6	60·3	53·3	54·6	49·5	50·5	·354	·368	3·9	4·1	1·4	1·7
August	58·4	59·0	56·0	54·4	51·9	50·7	·388	·372	4·3	4·2	1·2	1·5
September	65·0	54·8	53·3	51·5	51·7	48·2	·383	·334	4·3	3·8	0·6	1·0
October	48·4	48·2	46·0	45·8	43·4	43·1	·281	·279	3·2	3·2	0·6	0·6
November	42·4	42·2	39·9	40·0	36·8	37·1	·219	·222	2·6	2·6	0·6	0·5
December	41·2	38·7	39·1	36·7	36·6	34·3	·215	·200	2·5	2·3	0·5	0·4
Means, or totals	47·5	47·8	44·6	44·6	41·5	41·3	·270	·268	3·1	3·1	0·8	0·9

Degree of Humidity (Complete Saturation = 100.) — Weight of Air — Solar Radiation.

Month.	Highest.	Date.	Mean of Highest of 15 Years.	Lowest.	Date.	Mean of Lowest of 15 Years.	Mean.	Mean of 15 Years.	Mean Weight of a Cubic Foot of Air.	Mean of Fifteen Years.	Highest Reading of Maximum Thermometer in Rays of Sun.	Date.	Mean of Highest of Fifteen Years.	Mean Reading of Maximum Thermometer in Rays of Sun.	Mean of Fifteen Years.
	0—100	On	0—100	0—100	On	0—100	0—100	0—100	Grs.	Grs.	Deg.	On	Deg.	Deg.	Deg.
January	98	29th	98	73	18th	67	88	86	545	540	63·4	27th	60·7	51·3	48·1
February	97	8th	97	60	28th	70	85	86	546	547	81·7	26th	73·1	56·6	52·0
March	97	20th	88	69	5th	68	85	83	554	547	78·2	5th	85·1	60·2	82·4
April	98	28th	94	30	9th	65	85	78	543	540	93·2	10th	93·0	72·5	74·2
May	93	12th	95	35	16th	47	70	73	527	537	107·6	17th	107·3	81·0	82·0
June	97	26th	97	46	6th	61	71	72	531	530	105·8	24th	112·7	84·0	88·2
July	94	3rd	90	48	1st	51	74	70	526	526	103·0	29th	115·0	98·1	82·5
August	96	2nd	92	51	20th	53	79	75	527	526	107·0	4th	112·6	88·6	90·0
September	97	29th	95	59	20th	58	89	79	528	530	87·8	10th	100·8	76·1	80·8
October	96	24th	97	58	2nd	63	83	83	537	537	80·0	7th	87·2	66·9	67·0
November	95	21st	96	62	28th	64	81	83	542	543	66·0	6th	71·8	54·0	55·1
December	99	26th	98	67	4th	65	84	84	549	548	67·6	2nd	57·3	49·5	48·5
Means, or totals	96		94	54		59	81	79	538	538	85·1		90·3	60·1	70·0

Wind. — Cloud.

Month.	Highest Estimated Strength.	Date.	Mean Estimated Strength.	Direction (Relative Proportion of at 9 a.m.): N.	NE.	E.	SE.	S.	SW.	W.	NW.	Mean Amount of Cloud.
	0—6	On	0—6	No.	No.	No.	No.	No.	No.	No.	No.	0—10
January	4·0	26th	1·0	0	1	0	8	0	11	4	7	7·5
February	2·5	11th	1·0	0	0	0	8	4	8	5	5	7·0
March	2·5	30th	1·0	0	7	2	6	0	3	1	12	6·3
April	2·5	23rd	0·9	0	0	3	5	0	3	14	5	6·6
May	2·0	2nd	1·0	0	8	3	0	1	8	4	7	6·8
June	2·0	13th	0·8	0	5	5	6	1	8	2	2	6·9
July	2·0	27th	1·0	0	3	0	2	5	4	13	4	6·2
August	3·5	10th	1·0	0	1	0	0	5	10	11	4	6·0
September	3·0	30th	1·2	1	8	1	5	0	8	3	6	7·3
October	3·5	25th	1·2	3	5	0	4	0	8	2	9	7·2
November	2·5	4th	1·1	0	3	0	3	0	16	0	8	7·1
December	4·0	12th	1·5	3	3	1	4	0	3	7	10	7·3
Means, or totals	2·8		1·1	7	44	15	49	16	90	68	79	6·8

Rain.

Month.	Number of Days it fell.	Amount Collected.	Greatest Daily Fall.	Date.	Mean of Fifteen Years.	Mean of Seven Years ending with 1882, 65½ft. above surface of ground.	Mean of 7 Yrs. endg. with 1882 at T'n Hall and Mid. Ry. Station on surface of ground.	Gr'ter fall on surface at Town Hall & Mid. Stn. than at 65½ft. above surface at Exch.: Depth in Inches.	Percentage of fall at Exch'ge.
	No.	Ins.	Ins.	On	Ins.	Ins.	Ins.	Ins.	Per cent
January	22	5·00	0·86	28th	2·61	2·209	2·474	0·265	11·2
February	16	1·62	0·26	7th	2·00	2·609	2·972	0·363	11·4
March	13	0·80	0·34	7th	2·16	2·776	3·260	0·484	11·7
April	9	2·64	0·85	28th	2·15	2·516	2·835	0·318	11·2
May	13	0·58	0·13	11th	1·81	2·103	2·277	0·174	10·8
June	21	3·51	0·86	29th	2·57	2·837	3·011	0·174	10·6
July	20	3·86	1·07	21st	2·85	3·401	3·641	0·240	10·7
August	16	2·09	0·09	3rd	2·84	3·654	3·892	0·238	10·7
September	22	8·23	1·34	26th	3·12	2·894	3·229	0·335	11·2
October	18	3·65	0·71	17th	3·50	3·640	4·012	0·372	11·0
November	22	3·11	0·49	6th	2·96	3·421	3·828	0·407	11·2
December	14	1·32	0·28	11th	2·82	3·681	4·170	0·489	11·3
Means, or totals	206	34·40	0·69		31·48	35·741	39·601	3·860	11·08

Yearly Maximum and Minimum Atmospheric Pressure, Temperature, Humidity, and Rainfall, from 1869 to 1883 inclusive.

Pressure. — Temperature.

Year.	Pressure, Highest: Reading of Barometer during Year.	Date.	Pressure, Lowest: Reading of Barometer during Year.	Date.	In Shade, Highest: Reading of Maximum Thermometer during Year.	Date.	In Shade, Lowest: Reading of Minimum Thermometer during Year.	Date.	Last and First Frost of Season: Date of Last Frost.	Date of First Frost.	In Sun's Rays, Highest: Reading of Solar Thermometer during Year.	Date.
	Ins.		Ins.		Deg.		Deg.				Deg.	
1869	30·290	Dec. 6	28·500	Feb. 1	85·2	Aug. 30	10·8	Dec. 28	Mar. 27	Oct. 20	127·7	Aug. 30
1870	30·284	Jan. 19	28·308	Jan. 8	85·0	July 25	16·6	Dec. 23	Mar. 30	Nov. 9	127·5	July 25
1871	30·162	Mar. 28	28·308	Jan. 16	84·0	Aug. 12	6·7	Jan. 1	April 11	Nov. 13	128·7	July 17
1872	30·156	April 5	28·070	Jan. 24	86·4	July 23	24·8	Mar. 27	Mar. 27	Nov. 19	124·8	Aug. 19
1873	30·338	Feb. 18	28·022	Jan. 20	88·8	July 23	19·2	Feb. 24	Mar. 14	Nov. 5	124·5	July 23
1874	30·476	Mar. 6	28·276	Dec. 11	80·9	July 20	15·0	Dec. 31	Mar. 12	Nov. 11	126·8	July 20
1875	30·305	July 7	28·484	Nov. 10	80·0	Aug. 17	13·0	Jan. 1	Mar. 22	Nov. 28	122·0	July 5
1876	30·300	Jan. 16	28·070	Dec. 4	87·6	July 17	23·0	Jan. 9	April 15	Nov. 9	125·6	July 16
1877	30·358	Oct. 5	28·300	Nov. 29	80·0	June 19	20·0	Mar. 1	May 4	Oct. 18	118·4	June 18
1878	30·320	Mar. 15	28·530	April 1	89·6	July 19	13·9	Dec. 26	April 8	Nov. 9	118·2	July 22
1879	30·352	Dec. 13	28·500	Feb. 10	74·4	July 30	13·2	Dec. 7	May 10	Nov. 14	101·2	Aug. 13
1880	30·332	Jan. 7	28·154	Nov. 16	81·3	Sep. 5	20·8	Jan. 20	Feb. 23	Oct. 20	112·0	Aug. 13
1881	30·382	May 10	28·250	Oct. 14	83·3	July 8	12·0	Jan. 28	April 21	Oct. 17	116·5	June 1
1882	30·544	Jan. 18	28·462	Mar. 1	77·4	Aug. 12	18·8	Dec. 11	April 18	Nov. 12	108·0	Aug. 9
1883	30·600	April 9	28·452	Sep. 2	76·2	July 3	19·8	Mar. 10	Mar. 29	Nov. 12	107·8	May 17
Means	30·339		28·310		82·7		17·1				110·1	

Humidity (Complete Saturation = 100.) — Rain.

Year.	Humidity, Highest: Degree of Humidity during Year.	Date.	Humidity, Lowest: Degree of Humidity during Year.	Date.	Total for Year.	Mean Yearly Rainfall at Town Hall and Midland Railway Station on surface of ground.	Greater fall on surface at Town Hall & Mid. Rly. Stn. than at 65½ft above surface at Exchange: Depth in Inches.	Percentage of fall at Exch'ge.	Greatest Daily Fall during Year.	Date.	Snow, Last and First Snow of Season: Date of Last Snow.	Date of First Snow.
	0—100		0—100		Ins.	Ins.	Ins.	Per cent	Ins.			
1869	99	Feb. 8	42	Sep. 24	24·480	......	......	......	0·870	Dec. 18	April 3	Oct. 9
1870	98	Jan. 29	40	July 14	24·120	......	......	......	0·820	June 18	Mar. 24	Nov. 16
1871	98	July 7	43	Nov. 2	21·640	......	......	......	0·985	June 18	Mar. 15	Nov. 15
1872	100	Mar. 22	45	Sep. 23	42·050	......	......	......	2·490	June 19	May 11	Nov. 13
1873	100	Dec. 11	41	Mar. 26	21·440	......	......	......	1·200	Aug. 4	April 25	Jan. 3, '74
1874	100	Feb. 8	42	May 18	23·560	......	......	......	0·740	Dec. 7	May 9	Nov. 28
1875	100	Jan. 23	43	July 6	30·280	......	......	......	1·700	Nov. 15	Mar. 12	Nov. 9
1876	99	Oct. 4	48	May 5	35·270	39·788	4·518	11·28	1·810	Oct. 9	April 12	Nov. 8
1877	100	Oct. 29	35	May 23	40·650	45·499	4·849	11·19	1·420	July 18	May 10	Oct. 15
1878	99	Jan. 13	53	Aug. 9	35·434	39·010	3·578	11·01	1·220	Aug. 14	April 1	Nov. 8
1879	100	Oct. 7	51	Dec. 12	28·017	30·298	2·281	10·82	1·020	June 8	May 7	Nov. 20
1880	99	Dec. 16	50	May 30	35·890	39·616	3·926	11·10	1·710	Oct. 27	Mar. 2	Oct. 27
1881	98	Oct. 14	38	May 31	36·434	39·892	4·458	11·26	1·435	Oct. 13	April 20	Oct. 29
1882	90	Nov. 5	35	May 18	39·583	43·103	3·420	10·86	1·608	Dec. 8	Mar. 21	Nov. 19
1883	99	Dec. 26	30	April 9	34·396	......	......	......	1·338	Sep. 26	Mar. 24	Nov. 10
Means	99		42		31·477	39·601	3·860	11·08	1·358			

EXPLANATION.

The observations are made at nine a.m., and, with the exception of maximum and minimum thermometer readings, again at three p.m.

The highest and lowest barometric readings for each month, also the monthly range, are given as recorded; while the mean pressure is deduced from bi-daily observations corrected for index error, capillarity, temperature, and diurnal range. To correct for altitude or reduce to sea level (the air temperature being 48 degrees and barometer reading 30 inches at sea level), add ·401 inch to the heights given.

The adopted mean temperature of air is deduced from the dry bulb and the maximum and minimum readings; the temperature of evaporation from the dry and wet bulb and the maximum and minimum readings. The dew point, elastic force of vapour, humidity, &c., are deduced from bi-daily readings of the dry and wet bulb hygrometer, by Glaisher's Hygrometrical Tables, sixth edition.

The solar thermometer has a black bulb enclosed in a vacuum.

The direction of the wind is recorded as indicated by vane, and not by the clouds. Its pressure is estimated by a scale ranging from 0 to 6, the square of the number giving, approximately for the locality, the pressure in pounds per square foot. The highest number of scale indicating 36lb. per foot has not hitherto been recorded at the Exchange, while at some more exposed meteorological stations in this country much greater pressures have been recorded by anemometer. Provision has been made for registering the direction and pressure of wind by anemometer from commencement of 1884.

The amount of cloud is estimated by a scale ranging from 0 to 10.

The rain gauge is fixed upon the top of central roof of the Exchange, at an elevation of 65½ feet above the surface of the ground and 395 feet above mean sea level. As rain gauges on the summit of buildings are generally found to collect less rain than when placed upon the surface of open ground adjacent thereto, steps were taken in 1875 to determine to what extent this was the case with the Exchange rain gauge, when two additional gauges were provided and fixed upon the surface of adjacent open spaces, one near to the Town Hall, the other near to the Midland Railway Station, between which the Exchange gauge is situate about midway, and the surface of ground about the same height. At both of these gauges, as well as at the Exchange gauge, daily observations were made from the commencement of 1876 to the end of 1882, a period of seven years, when the surface gauges were removed in consequence of the ground they occupied being no longer available for the purpose. The particulars of these gaugings are set forth in tables. The results show that the mean yearly rainfall on the surface of ground for the seven years ending with 1882 is 3·86 inches, or 11·08 per cent., greater than at the summit of the Exchange. The mean yearly rainfall recorded at the Exchange for the fifteen years ending with 1883 is 31·477 inches. By adding 11·08 per cent. thereto the mean normal rainfall of central Bradford for such period is found to be 34·964 inches per annum. There are good grounds for concluding that the smaller amount of rainfall collected on the Exchange—and on buildings generally—than on the surface of ground is due to the varying direction and force of wind there producing different currents and eddies, which prevent due precipitation on the top or ridge of roof where the gauge is fixed.

All the instruments with which the observations are made have been verified by comparison with the standards at Kew Observatory.